DOCUMENT RESUME

ED 424 180 SO 029 508

AUTHOR Anderson, Curt L.
TITLE Economics and the Environment.
INSTITUTION National Council on Economic Education, New York, NY.
ISBN ISBN-1-56183-482-3
PUB DATE 1996-00-00
NOTE 251p.
AVAILABLE FROM National Council on Economic Education, 1140 Avenue of the Americas, New York, NY 10036 ($49.95).
PUB TYPE Guides - Non-Classroom (055)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Consumer Education; *Economics; *Economics Education; *Environmental Education; Instructional Materials; Secondary Education; Social Studies

ABSTRACT

This packet of lessons focuses on the complementary relationship between economic well-being and the natural resources of the environment. Students gain insight into a variety of environmental issues and learn to use economic analysis to understand these issues and seek solutions. The book contains 20 lessons divided into seven units. The units are entitled: (1) "The Environment and the Economy" (2 lessons); (2) "Getting the Most Value from Natural Resources" (3 lessons); (3) "The Economic Roots of Environmental Problems" (3 lessons); (4) "Finding Solutions When Markets Cannot" (3 lessons); (5) "Implementing Environmental Solutions" (3 lessons); (6) "The Management of Natural Resource Stocks" (3 lessons); and (7) "Economic Development in a Finite Environment" (3 lessons). (EH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 424 180

Curt L. Anderson

SO 029 508

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY

Betty P. Rauch

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2A

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Economics America

National Council on Economic Education

Economics and the Environment

Curt L. Anderson

OVER 45 YEARS
National Council on Economic Education
SINCE 1949

Economics America
National Council on
Economic Education
A partnership of education, business, and labor

AUTHOR

Curt L. Anderson is Director of the Center for Economic Education and Professor of Economics at the University of Minnesota, Duluth. His research interests are in the fields of natural resource and environmental economics, as well as economic education. His work has appeared in the *Journal of Environmental Economics and Management, Journal of Environmental Systems,* and *Growth and Change*. In addition his teaching ideas have appeared in the *Journal of Economic Education, College Teaching, Great Ideas in Teaching Economics,* and the National Council on Economic Education's curriculum journals, *The Senior Economist* and *The Elementary Economist* (now, *Economics for Kids*). He has received teaching awards from his University and in the National Awards for Teaching Economics for his contributions to economic education instruction.

Copyright © 1996, National Council on Economic Education, 1140 Avenue of the Americas, New York, NY 10036. All rights reserved. The activities and worksheets may be duplicated for classroom use, the number not to exceed the number of students in each class. Notice of copyright must appear on all pages. With the exception of the activities and worksheets, no part of this book may be reproduced in any form or by any means without permission in writing from the publisher. Printed in the United States of America.

ISBN 1-56183-482-3

5 4 3 2 1

CONTENTS

Acknowledgments iv
Foreword v
Preface vi
Using *Economics and the Environment* vii
Overview ix

UNIT 1: THE ENVIRONMENT AND THE ECONOMY

Lesson 1 Give Me a Hamburger and a Side Order of Environmental Quality! 2
Lesson 2 Moon Rocks, Golf Balls, and the Flow of Natural Resources Through an Economy 15

UNIT 2: GETTING THE MOST VALUE FROM NATURAL RESOURCES

Lesson 3 What Are Spotted Owls, Timber Products, and Magical Stones Really Worth? 28
Lesson 4 The Cost of Pollution: What is Being Given Up? 39
Lesson 5 How Clean is Clean Enough? 52

UNIT 3: THE ECONOMIC ROOTS OF ENVIRONMENTAL PROBLEMS

Lesson 6 It's Fine as Long as It's Mine—All Mine! 64
Lesson 7 We're All in This Together! 78
Lesson 8 Don't Rain On My Parade! 90

UNIT 4: FINDING SOLUTIONS WHEN MARKETS CANNOT

Lesson 9 Weighing the Pluses and the Minuses: Benefit-Cost Analysis 104
Lesson 10 Measuring the Value of Environmental Products 115
Lesson 11 Is Life Truly Priceless? 124

UNIT 5: IMPLEMENTING ENVIRONMENTAL SOLUTIONS

Lesson 12 Negotiate or Take Them to Court? 136
Lesson 13 Regulation: Is Just Saying "No" Enough? 147
Lesson 14 Buying Environmental Quality at Discount Prices 159

UNIT 6: THE MANAGEMENT OF NATURAL RESOURCE STOCKS

Lesson 15 Halloween Treats and Nonrenewable Resources 172
Lesson 16 The Extinction of Chickens and Mosquitos— Not! 181
Lesson 17 Crying "Wolf!" About Running Out of Natural Resources 190

UNIT 7: ECONOMIC DEVELOPMENT IN A FINITE ENVIRONMENT

Lesson 18 Recycling: A Tale of Two Markets 202
Lesson 19 How Many Children Can Mother Earth Stand? 213
Lesson 20 Toward a Sustainable Future? 225

Glossary 234

ACKNOWLEDGMENTS

Many individuals have influenced lessons in *Economics and the Environment*, as they reflect classroom testing and feedback from educators in several different settings over the years. Many of these helpful contributors will go unnamed here, but I wish to recognize those who gave significant assistance with this version of the publication.

Curt L. Anderson
Duluth, Minnesota

Content reviewers, editors and economic educators

Mark Evans, University of California, Bakersfield

Robert Highsmith, Vice President, Program and Research, National Council on Economic Education

Richard W. Lichty, University of Minnesota, Duluth

Claudia Parliament, Executive Director, Minnesota Council on Economic Education

S. Stowell Symmes, Director, School Services Division, National Council on Economic Education

Tom Tietenberg, Christian A. Johnson Distinguished Teaching Professor, Colby College

Pilot teachers

Dottie Barrett, West High School, Mankato, Minnesota

Steve Bogenrief, Osakis High School, Osakis, Minnesota

Tom Caldwell, Duluth East High School, Duluth, Minnesota

Don Charpentier, Apollo High School, St. Cloud, Minnesota

Maury Corrigan, South High School, Minneapolis, Minnesota

Jere Day, Milaca High School, Milaca, Minnesota

Terry Germ, Duluth East High School, Duluth, Minnesota

Barbara Hakala, Duluth Central High School, Duluth, Minnesota

Linda Hoff, Woodland Middle School, Duluth, Minnesota

Susan Jessico, Morgan Park Middle School, Duluth, Minnesota

Douglas Johnson, Cloquet High School, Cloquet, Minnesota

Kerry Juntunen, Wrenshall Schools, Wrenshall, Minnesota

Justine Kolbo, Cathedral High School, St. Cloud, Minnesota

Cheryl Lien, Duluth Denfeld High School, Duluth, Minnesota

Norman Lindahl, St. Cloud Technical High School, St. Cloud, Minnesota

Jim Norris, Osseo High School, Osseo, Minnesota

Ronald Nuebel, Northfield High School, Northfield, Minnesota

Jim Schwarzbauer, Hermantown High School, Hermantown, Minnesota

Mike Stenerson, Duluth East High School, Duluth, Minnesota

FOREWORD

Economics and the Environment is part of ***Economics****America*, a new generation of curriculum materials published by the National Council on Economic Education. ***Economics****America* is a national economic education program designed for K-12 teachers, drawing upon years of National Council experience in developing effective instructional materials and proven teacher education programs.

In *Economics and the Environment* teachers and students learn about the complementary relationship between their own economic well-being and the natural resources of the environment. In addition, students gain insights into a variety of environmental issues and learn to use economic analysis to understand these issues and to seek solutions. The lessons can be used in high school economics courses, environmental studies or social issues courses, and natural science courses. The classroom-tested lessons provide numerous activities and lead students toward discovery of important economic principles related to how the natural resources of the environment are used.

Printing of this publication was made possible through funding provided by Arco Foundation, Black & Veatch, DuPont deNemours & Co., Exxon Corporation, Mobil Foundation, Inc., PepsiCo Foundation, Premark International, Inc., and Union Carbide Foundation. We thank these donors for their intrest and support. We are indebted to Donald K. McIvor, a member of the Board of Directors of the National Council, for his tireless efforts generating financial resources sufficient to assure that this important project would succeed. We also thank the Minnesota Council on Economic Education and the content reviewers, editors, and teachers who piloted the materials, for their comments and constructive suggestions for improvement.

Curt Anderson deserves a special accolade for his skillful writing designed to create clear instructions for teachers. Serving as the primary content editor, which led to many rich discussions with Dr. Anderson, has been a rewarding professional experience for me. Joan Sullivan Baranski, publisher, National Council on Economic Education, and Richard Western, of the University of Wisconsin-Milwaukee, converted the final manuscript into an attractive, easy-to-use text.

Economics and the Environment joins other high quality ***Economics****America* curriculum materials produced by the National Council to help teachers prepare their students for active participation in the growing global economy. Publications include *Capstone: The Nation's High School Economics Course*; *U. S. History: Eyes on the Economy*; *Entrepreneurship in the U. S. Economy*; and *Teaching Strategies for International Trade*. We commend these instructional resources to teachers of secondary school students throughout the country.

S. Stowell Symmes
Director, School Services
National Council on Economic Education

PREFACE

Economic development and environmental protection are often seen as opposing goals. In fact, however, they are very much dependent on each other. Economic development based on degrading the natural resource stocks of the environment cannot be sustained. Nor can environmental protection be ensured unless people's basic needs and wants are first satisfied. *Economics and the Environment* is intended to illustrate the crucial role natural environmental resources play in both economic activity and economic development, to explain why at times these resources may be misused or overexploited, and to help teachers and students understand economic approaches that attempt to correct for these problems and achieve a sustainable balance between economic development and environmental protection.

The material in *Economics and the Environment* captures some of the basic economic principles of several specialty fields in economics including environmental economics, natural resource economics, and ecological economics. *Environmental and Natural Resource Economics* (Scott, Foresman and Company), by Tom Tietenberg, a content reviewer on this project, provides an excellent overview of these fields for teachers who wish to explore them in greater depth. The lessons themselves, shaped by numerous suggestions from high school teachers and their students, content reviewers, and my economic educator colleagues involved with the project, derive from lessons originally developed for a variety of courses and workshops offered for undergraduates and teachers through the University of Minnesota, Duluth and its Center for Economic Education.

High school students are very concerned about their own future and the future of the planet. Having the opportunity to work through lessons in *Economics and the Environment* with guidance from a knowledgeable, enthusiastic teacher will give students a better understanding of how both futures can be bright.

Curt L. Anderson, Director
Center for Economic Education
University of Minnesota—Duluth

USING *ECONOMICS AND THE ENVIRONMENT*

Economics and the Environment highlights the relationship between the natural resources of the environment and the economy, and it introduces students to the economic approach to analyzing environmental problems and finding solutions. It provides a wide range of activities suitable for use in high school courses in economics, government, environmental studies, natural sciences, social issues, global issues, and even mathematics.

Economics and the Environment is a resource manual consisting of an overview, lessons, and glossary. The overview provides a summary of the key concepts developed in the lessons and their relationship to each other. There are 20 lessons divided into seven units in the manual; each lesson focuses on specific economic and environmental concepts and principles from the fields of natural resource, energy, environmental, and ecological economics. The structure of each lesson is described below.

INTRODUCTION — tells briefly what the lesson is about and raises questions used to engage student interest.

ECONOMIC CONCEPTS — lists the economic concepts developed in the lesson. For definitions of the concepts, see the glossary.

ENVIRONMENTAL CONCEPTS — lists the environmental concepts discussed in the lesson. For definitions of the concepts, see the glossary.

OBJECTIVES — describe what students must do to demonstrate an understanding of the material contained in the lesson.

LESSON DESCRIPTION — Summarizes activities used to develop and illustrate lesson concepts.

TIME REQUIRED — suggests the approximate number of class periods needed to complete the entire lesson. Most lessons take one to two class periods, not including the Extension Activities.

MATERIALS — lists the Activities and other resources needed to conduct the games, simulations, or demonstrations used in the lesson.

PROCEDURE — describes a sequence of activities for use in teaching the concepts on which the lesson concentrates. The sequencing for most lessons is designed for student self-discovery of the principles involved, with the teacher acting as the guide. Suggested answers to questions and problems are printed in red type. While some steps in the procedure can be skipped, steps in the procedure generally build to some extent on preceding steps in the lesson. Steps are categorized by topical headings, but within each lesson all steps are numbered consecutively.

EXTENSION ACTIVITIES — provide interdisciplinary follow-up activities to extend learning and assignments that could be taught within other courses to

reinforce ideas taught in the lesson. These are listed by the subject areas (mathematics, geography, economics, science, etc.) where they are likely to be the most relevant.

The **GLOSSARY** provides definitions for all the key economic and environmental concepts and terms discussed in the lessons. At the end of each glossary entry in parentheses is a listing of all the lessons (by number) in which that term is explained or used.

The **ACTIVITIES** at the end of each lesson contain blackline masters to allow teachers to duplicate the recommended student activities and transparencies. These include case studies, graphs, tables, worksheets, and simulation materials. Each activity is headed by a lesson number (Extension Activities are coded with an "E").

While the lessons in *Economics and the Environment* are clearly related to and reinforced by each other, they are designed so that each can stand alone or be used in clusters, as inserts, within economics, history, government, science, or other related courses. Time constraints may prevent some teachers from using all the lessons in any one course. Some schools will want to offer an interdisciplinary one- semester elective course entitled *Economics and the Environment*. This program will serve as an excellent syllabus for such a course. Ultimately, the needs of students and the desires of their teachers will determine how these lessons are used. If they spark a few teaching ideas that work with students, the lessons will have done their job.

OVERVIEW

If they were asked what economics has to do with the environment, many people would likely respond that economic activity is what leads directly to environmental problems—economic activity is "bad" and environmental protection is "good." But in fact both economic activity and environmental protection are good. Both provide valuable products people use to satisfy their wants. The villain is not economic activity but economic scarcity—we just don't have enough productive resources (including people, capital, and the natural resources of the environment) to produce all the products (such as cars, medical care, and environmental quality) we want. Economics is the study of how people use scarce resources to satisfy their desire for goods and services. Thus economics can help us understand how and when the natural resources of the environment should or should not be used.

The lessons in this program are organized into seven units. Each unit concentrates on some key concepts in understanding how the natural resources of the environment are used, why they are sometimes overused or misused, and how economic incentives may be used to provide for both economic activity and environmental protection, now and in the future. These concepts are highlighted in the following unit summaries.

Unit 1: The Environment and the Economy

(Lessons 1 and 2)

This unit establishes the physical relationships between the environment and economic activity. The natural resources of the environment (air, water, ozone layer, fossil fuels, wildlife habitat, minerals, plant and animal species, the sun, deserts, beaches, etc.) help satisfy many of our basic needs and help people improve their living standards. Natural resources of the environment provide raw materials and energy to produce consumer products (goods and services such as cars, pizzas, medical care, and education), as well as capital goods (such as tools, machines, and buildings) that enable us to produce products in the future. Natural resources also provide us with environmental quality, a product we define to include all the life-support flows and amenity services provided directly to us, including clean air and water, protection from ultra-violet rays, scenic beauty, wildlife, places to hike, bike and swim, and waste assimilation (the transformation of wastes by natural processes).

Not that many years ago, the natural resources of the environment were abundant relative to our use of them. As we have increased the amount of products we produce, we have not only drawn down natural resource stocks; we also have increased the amount of wastes flowing back into the environment. This latter result is a consequence of the law of conservation of matter and energy, which tells us that while natural resources may be transformed, their basic elements cannot be physically created or destroyed. Thus, whenever we finish using the products we produce from natural resources, we must then figure out what to do with the inevitable wastes created. These wastes can and do disrupt the ability of our natural environment to produce environmental quality.

Today we see the production and consumption of consumer products at odds with the provision of environmental quality. Timber harvesting threatens the habitat of spotted owls. The burning of fossil fuels, which provide energy for industry and households, is linked to global warming and acid rains. Garbage generated from the products we use fouls our air and water and stuffs our landfills. Wilderness areas are converted into resorts with condominiums. Chemicals, heavy metals (such as mercury), CFCs (chlorofluorocarbons), dioxins, and nuclear wastes are produced, and the natural cleansing processes of the environment have little if any ability to absorb them.

Today natural resources, once thought to be limitless, are no longer abundant relative to the demands we place on them. They are scarce—they simply cannot provide all the products we want. Scarcity implies that choices must be made about how natural resources are to be used. Unit 1 focuses on the concept of scarcity and develops a model used by economists to depict the choices available to society when scarcity exists; this model is represented by the production possibilities curve. This curve illustrates which choices are feasible (possible) and which are not. In addition it enables one to consider the trade-offs people make when they decide how to cope with scarcity (more of one product must invariably come at the expense of some other product).

Lesson 1 considers the many products provided by the natural resources of the environment, emphasizing the trade-off between using natural resources to produce consumer products or using them to provide environmental quality. Lesson 2 focuses on how natural resources are transformed by economic activity into consumer products (and capital) and eventually into waste materials which must be placed back into the environment. The law of conservation of matter and energy plays a key role in this discussion. The eventual effect of wastes on environmental quality is shown to depend on the quantity of natural resources entering the economy and, of those, the quantity devoted to waste-management activities.

Unit 2: Getting the Most Value from Natural Resources

(Lessons 3, 4, and 5)

This unit presents the economic way of thinking about resources and their use. Natural resources may be used in a number of valuable ways. A tree, for example, may be left standing in a forest to provide wildlife habitat, carbon dioxide absorption, and scenic beauty, or it may be cut to provide wood for homes, or it may be used to provide paper to administer a pollution control agency. But, as Unit 1 shows, there are not enough trees to provide as much of all of these products as we would like. Scarcity implies that choices must be made.

In making choices it is natural to ask the value of one alternative use versus another, and it is reasonable to suggest that the alternative that yields the greatest value is the best choice. This essentially forms the basis of the economic approach to natural resource use: choose those uses of a resource which, over time, yield the greatest value to society.

Lesson 3 defines the value of a product according to how well it satisfies the economic wants of people. Value is measured by the maximum amount that people are willing and able to pay for the product (whether or not they actually have to pay). Thus, although they can not

be traded in markets and have no prices, products such as bald eagles, scenic views, a day spent fishing, the ozone layer, clean air, rainforests, wildlife habitat, and biodiversity have value, since they do satisfy people's desires. A major part of many environmental problems is that these values have not been accounted for in people's and businesses' economic decision making. Lesson 4 defines the cost of any choice made as the value of the next best alternative or opportunity not chosen. For example, the cost of building condominiums in a wilderness area would likely include the value of wildlife lost because of habitat destruction.

Lesson 5 introduces the economic criterion or goal of allocative efficiency. This criterion, based on the notion above, says resources should be used in a manner that maximizes the value society receives from them. The "right" amount of a product to produce is thus the amount that maximizes the net value society receives from the product—that is, one must balance the value gained when resources are used to produce or provide the product against the cost incurred (value forgone) by not being able to use these resources to produce something else. Among other things this criterion suggests that there is a "right" amount of the product, environmental quality, or, conversely, a "right" amount of pollution, which is defined as a loss of environmental quality. This amount in each case is not based on some physical or biological standard, but on society's willingness to sacrifice other products to get it.

Unit 3: The Economic Roots of Environmental Problems
(Lessons 6, 7, and 8)

This unit considers the ability of consumers, producers, and resource holders—trading in markets and motivated by self interest—to ensure that natural resources are used in the allocatively efficient manner—that is, allocated in the best way for society as a whole, as described in Unit 2. In general, for markets to achieve such results they must be competitive, and all property rights must be well-defined. With respect to the markets for natural resources of the environment, these conditions are often not met, and when they are not markets may produce the "wrong" (not allocatively efficient) amount of products. In particular, markets will tend to under-produce environmental quality relative to other products. Under-production of this sort results mainly from market participants not taking into account the full benefits and/or costs of their decisions.

Lesson 6 describes the necessary conditions for markets to achieve allocatively efficient results and focuses on the effect of property rights on economic incentives. For example, a lack of clear ownership rights to such resources as the ozone layer, whales in the open ocean, and the air over a city means people are free to use these resources as they want. Since no owner exists to manage or control how these resources are used, they will likely be overused or overexploited; the price to use them is essentially zero, but the cost is not (due to their scarcity). Lesson 7 shows that environmental quality is a public good. Because the benefits of environmental quality may be shared by many people and because it is difficult to exclude those who do not pay for these benefits, the true value of environmental quality is often understated, leading markets to under-produce it (that is, not

devote sufficient natural resources to its provision). Lesson 8 illustrates how not accounting for the benefits and costs associated with environmental quality shows up in other product markets as externalities and leads to inefficient amounts of these products being produced. For example, by not taking into account the value of the lost environmental quality brought about by acid rain, people who own and manage coal-fired power plants produce more electricity than is efficient (electricity appears to be a more valuable product to society than it really is, since not all the costs associated with producing it are accounted for by the producers).

Unit 4: Finding Environmental Solutions When Markets Cannot

(Lessons 9, 10, and 11)

For several reasons described in Unit 3, we cannot always rely on markets to achieve the "right" level of environmental quality or the "best" use of the natural resources of the environment (from the perspective of allocative efficiency); therefore, we must sometimes rely on more direct approaches. This unit describes how benefit-cost analysis is used to analyze such problems. The analyses essentially try to quantify all the benefits (value received by society) and costs (value which must be forgone) of producing or providing a product. The next step is to apply the criterion of allocative efficiency to determine how much should be produced. With respect to products provided by natural resources, the challenge is to assess accurately the value of the products (or the costs associated with their loss) when there is generally no market activity to show how much people are willing and able to pay.

Lesson 9 introduces the basic framework of benefit-cost analysis. Lesson 10 describes some techniques economists use to approximate the value of products that are not normally traded in markets—such as air quality, biodiversity, visibility, whales, and scenic canyons. By observing how changes in these products affect other products or resources for which there is a market, one can gain some insight into the value people place on them. Otherwise one can ask people directly how much they would be willing and able to pay for these products. Because environmental decisions so often involve life-and-death consequences, Lesson 11 applies some of the techniques of Lesson 10 to the problem of assessing the value of a human life—or, more precisely, the value of a reduction in the probability of death. Such values are important in decisions about problems involving environmental risk—e.g., in disposing of nuclear and other hazardous wastes.

Unit 5: Implementing Environmental Solutions

(Lessons 12, 13, and 14)

While the methods discussed in Unit 4 help us to find the best use of a natural resource when markets cannot, this unit looks at ways to ensure that the best use is the use that actually occurs. That is, how can we ensure that all the benefits and costs of resource decisions actually are taken into account by market participants? Lesson 12 considers two options: private negotiations between affected parties and settling environmental disputes in court. These options are most effective when property rights are defined, when the number of parties involved in the suit is small, and when the damages and liability for those damages are clear. For many environmental problems, these conditions are not met.

Lesson 13 considers the statutory or regulatory approach, in which rules and regulations regarding the use of many natural resources are established by the government. Regulation usually involves setting standards or limits on use, so that the government becomes the de facto manager of many natural resources (like waterways, air and water sheds, wilderness land, and wildlife stocks). While regulation sometimes brings society closer to the "right" level of environmental quality (that is, allocative efficiency is achieved), the regulatory approach is often not very flexible or adaptable to changing conditions and may end up achieving the "right" level by using far more resources than is necessary.

Lesson 14 considers economic approaches that provide market-like incentives. The first involves assessing an emission charge or tax on emissions into the environment. To the extent that these charges reflect the cost of lost environmental quality, they force emitters to take this cost into account as they make decisions. In the second approach tradable permits are either auctioned off or distributed by the government. Tradable permits allow their holders to emit a specified amount of some pollutant over a given time period. A market for such permits usually develops, and activity within the market sets a price for each permit, so that once again emitters are forced to pay for their use of the air sheds or waterways as disposal sites. An important advantage of market approaches is that they are typically very cost-effective—that is, they achieve the "right" level of environmental quality in the least costly manner available.

Unit 6: The Management of Natural Resource Stocks
(Lessons 15, 16, and 17)

This unit addresses the question of when natural resources should be used and the factors that affect the future availability of these resources. One important cost of depleting natural resource stocks today is the lost opportunity to use them in the future. Extending the concept of allocative efficiency suggests that natural resources should be used in their most valued way, either today or in some future period.

A natural resource may generally be classified as nonrenewable or renewable, depending on the ability of the environment to regenerate the resource in question. Nonrenewable resources include fossil fuels (such as oil, coal, and natural gas) and minerals (such as iron ore, tin, zinc, and copper). Renewable resources include most plant and animal species, as well as surface water and solar energy.

Lesson 15 considers how nonrenewable resources are used up over time. Markets can signal growing resource shortages (through higher prices), thus setting in motion forces which alleviate those shortages: conservation, increased exploration, and substitution. Lesson 16 discusses renewable resources: how they are harvested over time and how they may be managed to provide sustained yields. Resource holders are shown in general to have the incentive to manage a renewable resource stock so that it produces sustained yields over time. Extinction threats are likely to arise when nobody owns the stock or its habitat. Lesson 17 addresses the general question of resource scarcity—are we really running out? The limit on our use of nonrenewable natural resources is shown to be determined not by their physical availability (which is quite large relative to our current use levels), but rather by how much society is willing and

able to pay to extract and process the resources. In other words, we are not running out of nonrenewable resources, but we may be running out of cheap nonrenewable resources.

Unit 7: Economic Development in a Finite Environment

(Lessons 18, 19, and 20)

The final unit considers the dual goals of producing environmental quality and achieving economic development. Economic development may be defined as per capita increases in the production of goods and services over time. Sustaining a given production level, and increasing it over time, requires sustainable raw material and energy flows from natural resources. Sustaining a given level of environmental quality similarly requires that some natural resources be allocated to waste management and others simply left alone. Given that many natural resources are renewable, so that sustained flows from them are possible (e.g., the flow of biological resources, solar energy, and surface water), sustainable levels of production and environmental quality appear to be possible. With technological advances in the way we use and reuse resources, it is also possible to envision increasing levels of goods and services and environmental quality as we become able to produce more with the same flow of natural resources. But can such increases keep pace with the growth of population?

Lesson 18 discusses recycling both as a way to reduce the effect of waste flows on environmental quality and as a source of additional natural resources to help conserve on our use of virgin resources. These benefits of recycling, however, must be weighed against the costs of collecting, storing, transporting, and processing recyclable materials—all processes that use other resources.

Lessons 19 and 20 discuss the economic realities of environmental constraints. Lesson 19 considers the demands placed on the natural resources of the environment as a result of population growth, as well as the demands for increased per capita production. While more people represent more human resources available for production, a limited amount of available natural resources suggests diminishing returns to production. Finally, Lesson 20 considers some futuristic projections. Ecologists look to the future with pessimism; they foresee growing resource shortages bumping up against capacity limits and environmental degradation. Economists foresee price adjustments directing resource substitutions, technological advances expanding limits, and economic development allowing for the provision of increased environmental quality. These adjustments, however, will depend heavily on how well market participants take into account the true costs of their choices (as demonstrated in many of the previous lessons). If students grasp this point—that future developments depend on the choices we make now—they will have gained much from their study of *Economics and the Environment.*

UNIT 1

THE ENVIRONMENT AND THE ECONOMY

GIVE ME A HAMBURGER AND A SIDE ORDER OF ENVIRONMENTAL QUALITY!

INTRODUCTION

All the goods and services that help meet our economic wants cannot be bought at a fast-food restaurant, the corner convenience store, the mall, or even the local discount retailer. The natural resources of the environment provide many very important goods and services directly to us, such as drinkable water, breathable air, protection from ultra-violet rays, breathtaking vistas, and plant and animal species that are interesting, beautiful, and useful. Unfortunately, the environment's ability to produce such things is limited. In this lesson students consider the various goods and services produced by the economy, goods and services provided by the environment, and the relationships among them.

ECONOMIC CONCEPTS

Economic Wants
Natural Resources
Product
Good
Service
Scarcity
Trade-off
Production Possibilities Curve
Consumption
Production

ENVIRONMENTAL CONCEPTS

Recycling
Wastes
Waste Management
Assimilation
Life-support Products
Amenity Services
Landfilling
Incineration
Energy
Environment
Environmental Quality
Biodiversity

OBJECTIVES

- Describe the goods and services provided directly and indirectly (through the economy) by the natural resources of the environment.
- Describe environmental quality as a product which satisfies people's economic wants.
- Explain the trade-offs between products produced in the economy and those provided by the environment.
- Discuss society's alternatives with respect to how it uses the natural resources of the environment today and in the future.

LESSON DESCRIPTION

Students use a diagram to visualize the relationship between the natural environment and the economy. The diagram highlights the valuable products provided by the natural resources of the environment. One of these products, environmental quality, is defined, and students are asked how economic activity might affect the amount of this product society receives. Production possibilities curves are developed and used to illustrate the limits imposed by finite stocks of natural resources and the trade-offs these limits imply. Finally, students consider how these limits might change in the future.

TIME REQUIRED

Two class periods:

Day 1: Steps 1-6

Day 2: Steps 7-18 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 2, 3, and 4 (plus Activity 5E)

PROCEDURE

Products of the Environment

1. Distribute and discuss Activity 1.

   First note that the general objective of economics is to satisfy people's economic wants as much as is possible given limited resources—or, in terms of the diagram, to make the "smiling faces" as happy as possible. The diagram illustrates the flow of materials and products between the environment and the economy, through which the objective is achieved.

   The environment may be described by the stock of natural resources which make it up. These natural resources can satisfy people's economic wants in basically two ways: (1) indirectly, as inputs (energy and raw materials) used in the production of goods and services (consumer and capital products) or (2) directly, by providing life-support and amenity products. These latter products are aggregately referred to as environmental quality.

   Unfortunately, production and consumption activities inevitably result in the creation of wastes (see Lesson 2 for a complete discussion) which are eventually placed back into the environment. Fortunately, the environment has natural processes that help to assimilate some of these wastes. The amount and nature of these wastes plus the amount of natural resources taken out of the environment for production will affect the stock of natural resources available and the ability of those resources to provide production inputs and environmental quality in the future. To reduce the impact of the wastes, society may choose to devote some resources to waste management activities such as recycling, incineration, landfilling, or other treatment.

   As a final point, note that the economy is placed within the environment in order to highlight the physical limits placed on the economy by a finite environment.

2. Ask students to suggest specific examples for each term used in the diagram.

   Answers might include:

   - *Stock of Natural Resources:* minerals, animals, plants, wetlands, oceans, forests, ozone layer, air, fossil fuels, canyons, the sun
   - *Energy/Raw Materials:* oil, natural gas, coal, solar energy, wood, biomass/tuna, cattle, water, air, timber, iron ore, mercury, crops
   - *Goods and Services:* hamburgers, pizza, cars, computers, CDs, haircuts, education, medical care, movies, clothes, transportation, soft drinks, houses
   - *Wastes (from Production):* sawdust, paper pulp, solvents, scrap metals, ash, gases (carbon dioxide, sulfur dioxide, nitrogen oxides, etc.)
   - *Wastes (from Consumption):* packaging, soft drink cans, sewage, newspapers, junk cars,

garbage, old clothes and furniture
- *Recycled Materials:* aluminum, newsprint, plastics, glass, scrap metal, paper
- *Wastes (into the Environment):* gases (from incineration), garbage and demolition materials (from landfilling), oil spills, litter, "treated" sewage
- *Environmental Quality:* life-support products: air, water, ultra-violet ray protection, carbon dioxide absorption, habitat; amenity services: hiking through a forest, spotting a plant or animal species, viewing a sunset, swimming in a lake, enjoying biodiversity.

3. **Assign the class to use the diagram to describe how trees in a forest may be used indirectly or directly to satisfy consumers' wants. Discuss responses:**

Indirectly: harvested trees (timber) enter the production sector of the economy as a raw material input and exit production as paper or wood products and wastes (paper pulp). The paper or wood products (furniture, homes, pencils) satisfy consumer wants and then leave the consumption sector of the economy as waste paper, demolition materials, broken furniture, etc. Some of these wastes are recycled (newsprint, wood burned for energy), while the remainder is placed back into the environment through incineration or landfilling.

Directly: trees provide direct services to consumers by absorbing carbon dioxide, providing habitat for wildlife, providing cool shade, providing beautiful scenery, and providing something to climb. Thus, trees can supply environmental quality directly to consumers and can supply other goods and services indirectly.

4. **Note in summary that the natural resources of the environment are (1) a source of raw materials and energy, (2) a depository for wastes, (3) an assimilator of wastes, (4) a provider of environmental quality (life-support and amenity products).**

Environmental Quality

5. **Distribute a copy of Activity 2 to each student.**
6. **After about 10 minutes, discuss the answers.**

a. Some possibilities include:
- buried wastes contaminating groundwater supplies
- gases and particulates in the air reducing air quality
- CFC (chlorofluorocarbons) emissions leading to ozone depletion
- sewage releases leading to unswimmable rivers
- carbon dioxide emissions leading to global warming
- litter spoiling a scenic view
- acid rain destroying a forest

b. Some possibilities include:
- scenic canyons are dammed up to produce electricity
- scenic forests are cut to produce wood products
- instream flows which support fish life are reduced to provide water for industrial, residential, and agricultural needs
- biodiversity is reduced as more land comes under development
- wetland habitats are lost when land is drained for other uses

c. Some possibilities include:
   - the amount of wastes is greater than the environment can assimilate because of population growth and growth in the amount of goods and services produced for each person
   - the nature of wastes is much more complex—natural processes are not able to assimilate certain chemicals, heavy metals, nuclear wastes, etc.

d. Some possibilities include:
   - catalytic converters are produced to reduce auto emissions
   - waste treatment plants are built to process sewage wastes
   - "scrubbers" are installed on smokestacks to remove sulfur
   - lining landfills with clay or synthetic material to prevent leakage and groundwater contamination

e. Answers will vary. Focus students on the products (life-support and amenity products) that constitute environmental quality.

Illustrating the Trade-offs

7. **Ask students why we can't expect to expand our use of the environment as a source of energy/raw materials and a depository for our wastes without losing some environmental quality.**

   Discuss answers: the stock of natural resources is finite or limited. It is scarce.

8. **To demonstrate this scarcity and the resulting trade-offs involved, distribute Activity 3 to each student and tell the students they are going to "draw a picture" of the alternative ways in which a natural resource of the environment might be used. Tell the students that society has six million acres of land (the scarce natural resource in this case) which can be left as a wilderness preserve (providing hiking and "back-to-nature" experiences, habitat, biodiversity, and other "wilderness" products) or mined to produce minerals (providing material for numerous products such as cans, cars, computers, buildings, and tools). The mining of the minerals will, however, disrupt the land's ability to provide wilderness products.**

9. **Explain the following: Column 1 shows different amounts of land that could be devoted to wilderness preserves. Column 2 shows the amount of land that would remain for mineral production in each case (which is just six minus the amount in Column 1). Column 3 shows the amount of minerals which could be produced given the amount of land shown in Column 2.**

10. **Remind students that mathematicians and economists place numbers on graphs in specific ways. Graphs are wonderful ways to show and then analyze relationships between two variables. In mathematics, the vertical axis is always the y-variable and the horizontal axis is the x-variable, and points are expressed, as (3,9), where the first number is the x coordinate and the second is the y coordinate. (Later you can remind them that economists always put the price variable on the vertical axis and quantity on the horizontal axis when**

constructing supply and demand curves).

11. Then assign students, working individually, to plot the alternatives by using the values in Columns 1 and 3 (that is, the points (0,24), (1,23), (2,21), (3, 18), (4,14), (5,8), and (6,0), where the first number in each pair denotes the amount of wilderness preserves and the second the amount of minerals produced). Next students should connect these points to form a smooth curve and label the alternative (0,24) point A, (2,21) point B, (4,14) point C, and (6,0) point D. Note that such a curve is called a "production possibilities curve" because it separates those alternatives that cannot currently be produced (those lying outside the curve) from those that can be (those lying on or inside the curve), given today's technology and natural resource availability.
12. Also direct the students to plot and label alternative (2,14) point E and (4,21) point F (note that these are not on the curve).
13. Ask students to review their work for steps 11 and 12; then, working on a separate sheet of paper, they should answer questions 3(a-f). Answers follow.
    a. A and D.
    b. B and C.
    c. There is not enough land to produce alternatives beyond the curve—such as point F.
    d. Yes, and if it is done efficiently, two million acres of land would be available for other uses.
    e. It has a negative slope indicating that as more land is used for wilderness preserves, less mineral production is possible (or conversely, increased mineral production means fewer wilderness preserves are possible).
    f. It depends on how much society values the products produced with the minerals relative to the products provided by wilderness preserves.

Applying the Production Possibilities Curve

14. Divide the class into four cooperative groups. Distribute Activity 4. Assign each group to work on one of the scenarios described.
15. Allow 10 minutes for the groups to complete the activity; then have the groups report to the class.
16. Summarize by noting that most environmental choices involve trade-offs (as demonstrated by the production possibilities curve) because of the scarcity of natural resources and the limits of current technology.

Future Possibilities

17. Ask students to suggest factors that would allow a society to expand its production possibilities—that is, allow it to produce alternatives that were not possible before.
    Answers should include the principal determinants of economic growth: discovery of additional natural resources, increases in population, investment in capital, improved education and training (investment in human capital), and advances in technical know-how.
18. Ask the class how advances in technical know-how can enable a society to produce alternatives it previously could not produce without an increase in the amount of raw materials or energy into the economy.

Fewer resources are required to produce the same output (for example, consider the room-filling computers of yesterday compared to the hand calculators of today), which frees up resources to produce more of something else. Alternatively, the same resources produce more output (for example, a car can travel more miles with a gallon of gas).

EXTENSION ACTIVITIES

Environmental Studies

19. Assign students to find a current story in a newspaper or magazine which discusses an environmental problem. Ask them to write up the issue in the context of Activity 1.
20. In particular students should answer the following questions related to the issue chosen:
    a. What is being lost in terms of environmental quality?
       For example, reduced life-support products (poorer air or water quality) or reduced amenity services (fewer scenic areas, wildlife species, or less visibility).
    b. What waste or energy/raw material flow has led to this loss?
       Waste examples might be carbon dioxide, sulfur, or hazardous waste emissions; energy/raw material flow examples might be hydroelectric energy (causing the loss of a scenic canyon or rare species) or timber (causing the loss of carbon dioxide absorption, habitat, or aesthetics).
    c. What goods and services did consumers receive which produced the wastes?
    d. If wastes are involved, did they come from production, consumption, or both?

Science

21. Discuss the role of one or more of the mineral (carbon, oxygen, nitrogen, phosphorus, sulfur, etc.) cycles in transforming materials from one form to another (i.e., the natural assimilation or purification mechanisms of the environment).
22. Discuss the hydrologic (water) cycle and note where wastes might enter and affect the quality of the water.

Math/Economics

23. Some students may question why the production possibilities curve is not just a straight line. That is, in Activity 3, why doesn't mineral production just fall by four tons each time another million acres is used as a wilderness preserve?
24. To explain why, ask the following: "Are mineral deposits evenly spread out throughout the world?"
    No. For example, the United States has quite an abundance of copper and zinc (relative to other countries), while China has most of the world's reserves of magnesium and tungsten. Thus, all land is not equally capable of producing minerals.
25. Ask students to explain why this might cause the production possibilities curve to take the shape it does (at first, little mineral production is lost as land is used for wilderness preserves; then the loss starts to grow).
    It is possible for society to get the first million acres of wilderness preserves by giving up those acres with the smallest amount of minerals. As it attempts to get

more acres of wilderness preserves, it must start giving up land which has greater and greater amounts of minerals and so the loss of mineral production grows.

26. The actual shape of the production possibilities curve determines how much of one product must be forgone to get more of another. These shapes may be described by mathematical formulas. Assign geometry and algebra students to graph the following equations by plotting several points (in the first quadrant only where both x and y are positive numbers).
    a. $X^2 + Y^2 = 100$
    b. $X + Y = 10$
    c. $X^2 + 10Y = 100$
    Some sample points:
    a. (10,0), (8,6), (6,8), (0,10)
    b. (10,0), (8,2), (6,4), (5,5), (3,7), (1,9), (0,10)
    c. (10,0), (8,3.6), (5,7.5), (3,9.1), (0,10)]
27. Ask students to identify the general shape of each graph.
    A quarter of a circle, straight line, part of a parabola, respectively.
28. Ask students to discuss how Y changes as X increases (i.e., the slopes of the curves).
    Y decreases as X increases—the slope is negative.
    If these graphs represent production possibilities curves, what differences are implied by equations (a) and (b)?
    There are more alternatives in case (a); in case (a), getting more of X takes increasingly more Y, while in case (b) it takes a constant amount of Y.

History

29. Assign students to research the conservation movement in the United States. This represents an attempt by "consumers" to preserve and enhance the quality they receive.

Family Studies

30. Plan an "environmental vacation" (e.g., visit a wilderness area, go canoeing, go hiking in the mountains, go birdwatching, relax on a beach, etc.).
31. Make an itinerary; list goods and services (provided directly by the environment) that you hope to enjoy; describe the amount of "other" goods and services you will use (gas, lodging, food, etc.).

Community

32. Invite a speaker from the local water utility to discuss with your class where your community gets its drinking water, the initial quality of that water, and what, if any, are the potential threats to the quality of the water source.

Economics

33. Show the video, "Resources and Scarcity: What is Economics All About?" from Lesson 1, *Economics U$A.* Discuss the trade-off in the case of the Alaska Land Act in terms of Activity 1 (oil and mineral inputs to produce goods and services versus wilderness preservation [environmental quality]). Note that the trade-off may be illustrated by a production possibilities curve.
34. Explain to students that economic growth is typically measured in terms of changes in real GDP, Gross Domestic Product (the market value of all final goods and services produced in the economy). This measure has been strongly criticized by environmentalists. Ask: What are

some possible reasons for this criticism? Discuss responses.

Products produced by the environment are provided directly to consumers and so do not pass through markets (thus, they are not counted); the depletion of natural resource stocks (which reduce their ability to provide energy/raw material flows and environmental quality today and in the future) is not treated like the consumption of capital—as a cost or loss to society.

35. **Ask students to suggest their own measures of economic growth.**

Science/Economics

36. **Distribute Activity 5E and ask students to read it. Discuss the direct and indirect products provided by biodiversity in terms of Activity 1. Discuss responses.**

The indirect provision of products (coffee, rubber, medicines, etc.) as well as the direct provision of products (pest control, ecological "insurance", natural assimilation of wastes, etc.

37. **Ask: How is biodiversity part of a trade-off?**

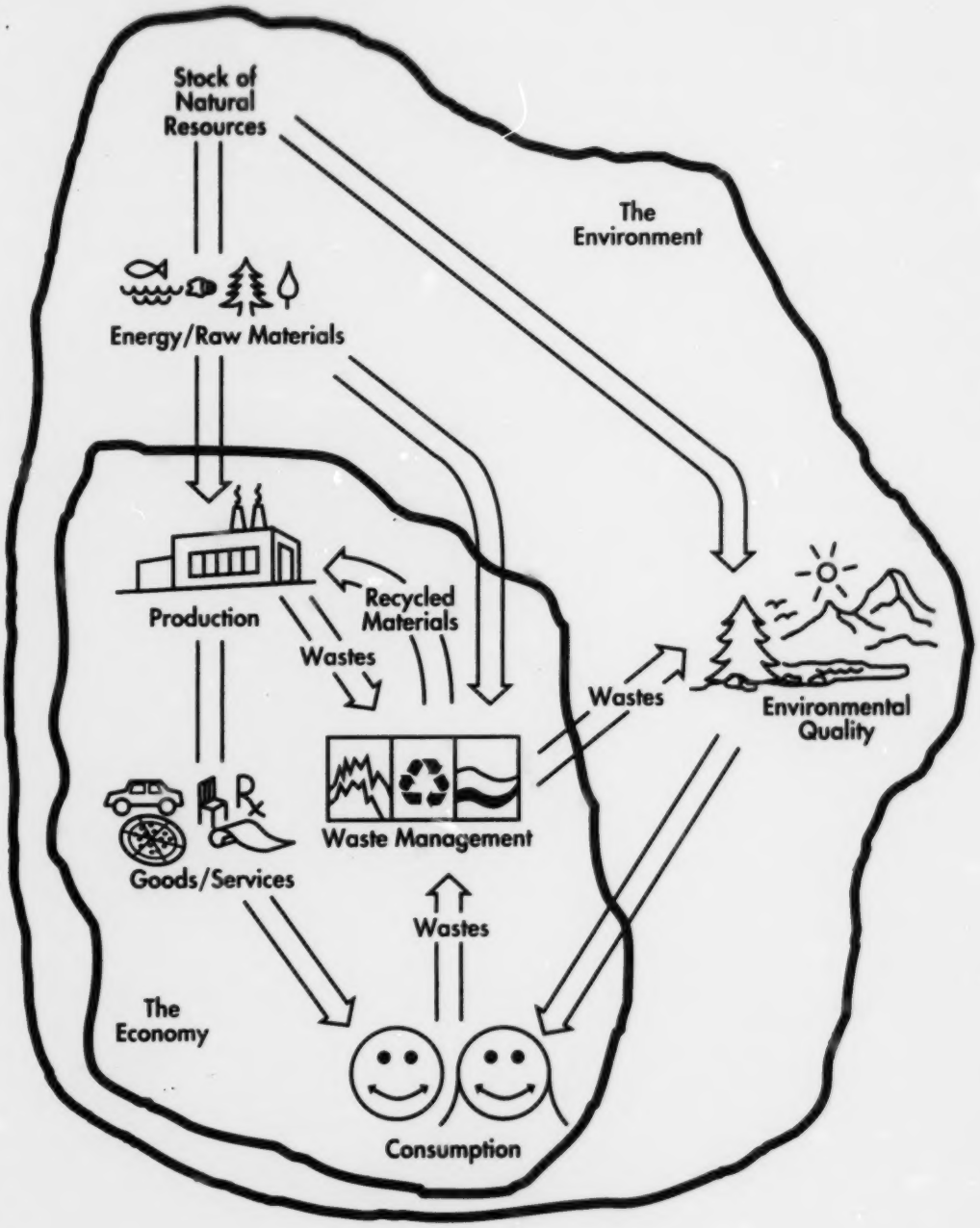
When ecosystems are destroyed to produce products such as timber or crops, biodiversity is lost.

38. **Ask: How does preserving biodiversity lead to new possible alternatives in the future?**

Undiscovered species and uses of them can help produce new products.

ACTIVITY 1

THE ENVIRONMENT AND THE ECONOMY



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

THINKING ABOUT ENVIRONMENTAL QUALITY

Economists think of environmental quality as a product like any other product — for example, computer games, medical care, pizzas, haircuts, or clothes. It is something that satisfies people's wants. But what is it exactly? Generally, it is defined by the amount of life-support products (such as clean air to breathe, drinkable water, protection from ultra-violet rays from the sun) people receive and the amenity services (activities supported by the natural resources of the environment such as hiking, sightseeing, swimming, relaxing, wildlife preservation) they receive. Given this, answer the following questions:

a. List some examples of how wastes placed back into the environment can reduce the amount of environmental quality people receive.

b. List some examples of how extracting or harvesting natural resources to produce goods and services can reduce the amount of environmental quality people receive.

c. Give some reasons why losses of environmental quality are more likely today than 200 years ago.

d. List some examples of how environmental quality can be improved by devoting resources to waste management.

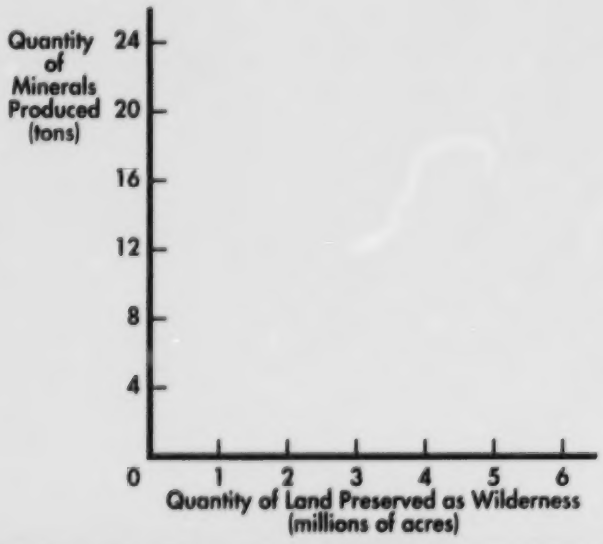
e. How does the environmental quality of your area compare to that in other areas?

ACTIVITY 3

WILDERNESS AND MINERALS: THE ALTERNATIVES

COLUMN 1	COLUMN 2	COLUMN 3
Land Preserved as Wilderness (millions of acres)	Land Remaining for Mineral Production (millions of acres)	Amount of Minerals Produced (tons)
0	6	24
1	5	23
2	4	21
3	3	18
4	2	14
5	1	8
6	0	0

1. Plot the possible alternative amounts of wilderness preserves and minerals this six million acres of land can produce, using the figures in Columns 1 and 3.
2. Find and label the following points: (0,24) as A, (2,21) as B, (4,14) as C, (6,0) as D, (2,14) as E, and (4,21) as F.
3. Respond to the following questions, writing your answers on a separate sheet of paper.
   a. Which points on the curve represent "all or nothing" alternatives?
   b. Which points on the curve represent "a little of this and a little of that" alternatives?
   c. How does the curve reflect scarcity?
   d. Is it possible to produce option E?
   e. How does the curve illustrate trade-offs?
   f. Which alternative represents the "best" choice?



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

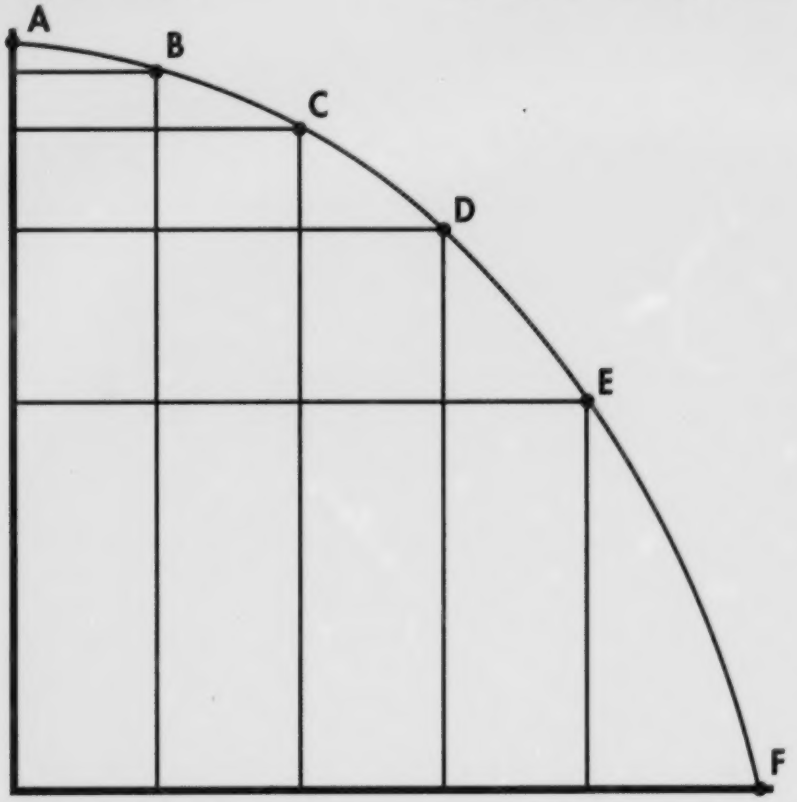
DESCRIBING ENVIRONMENTAL CHOICES

Suppose the graph below shows the production possibilities for:

SCENARIO 1: Land in a given region which may be used for landfill sites or producing agricultural products.
SCENARIO 2: Capital resources which may be used to produce electronic products or air pollution control equipment.
SCENARIO 3: Oil for producing energy today or in the future.
SCENARIO 4: A stand of trees which may be used to produce timber products or preserved for wildlife habitat.

Directions:

- Label the vertical and horizontal axes for your assigned scenario.
- Explain why there are alternatives outside this curve that cannot be chosen.
- Describe in general terms how the alternatives A through F differ from each other.
- Discuss why different people might choose a different alternative as the "best" one.
- Select one member of your group to report your findings to the class.



ACTIVITY 5E

BIODIVERSITY

Biodiversity (biological diversity) is best defined in terms of three related concepts: genetic diversity, the variability in the genetic makeup among individuals within a single species; species diversity, the variety of species throughout the world; and ecological diversity, the variety of ecosystems (forests, lakes, etc.) or biological communities. Currently it is estimated that 40 to 80 million species, each with many variations in its genetic makeup and living in a variety of settings, inhabitat the Earth.

It is further estimated that between 50% and 90% of these species have homes in the tropical rain forests which comprise only about one-sixteenth of the Earth's land mass. Given the current rate of forest destruction and degradation, an estimated one million species will become prematurely extinct in the next 15 years. So what?

Plant and animal species are the source of many food products including coffee, nuts, chocolate, and fruits. In fact, many of the faster-growing, disease-resistant strains of rice, wheat, and corn were developed from strains grown in the tropics. Plant and animal species also provide raw materials for producing rubber, dyes, and oils, and they supply the necessary ingredients for one-fourth of the world's medicines—including life-saving drugs to treat cancer, leukemia, heart disease, and multiple sclerosis.

These species also provide direct, unmarketed goods and services. They provide us with resource recycling, purification systems, and natural pest control. Most important, they provide us "insurance." Every living species stores genetic information that allows the species to adapt to changing environmental conditions. This stock of knowledge provides us insurance against environmental disasters.

Biodiversity is important not only for the goods and services it provides today but also for those it may provide in the future. It is estimated that less than 1% of all tropical forest species have been examined for their economic potential in providing goods and services. A plant or animal yet uninvestigated may supply the necessary ingredient for a drug to cure AIDS, a chemical which may be substituted for a hazardous material in a production process, or a new strain of disease-resistant wheat.

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

MOON ROCKS, GOLF BALLS, AND THE FLOW OF NATURAL RESOURCES THROUGH AN ECONOMY

INTRODUCTION

NASA's Apollo missions to the moon brought back many samples of lunar soil and rocks. They also left behind lunar vehicles, other assorted equipment, some U.S. flags, and a golf ball shot by astronaut Alan Shepard. Other than these things and a few other "space exchanges" (including solar energy!), few natural resources ever leave Earth or enter its atmosphere. In this lesson students focus on the role played by natural resources in producing goods and services and on what happens to goods and services once we are done using them.

ECONOMIC CONCEPTS

Economic Wants
Goods and Services
Productive Resources (Human, Capital, Natural)
Production
Consumption

ENVIRONMENTAL CONCEPTS

Energy
Energy Conversion
Materials Processing
Fossil Fuel
Law of Conservation of Matter and Energy
Waste Management
Incineration
Landfilling
The "Four Rs": Reduce, Reuse, Recycle, and Refine
Wastes
Pollution

OBJECTIVES

- Provide examples of natural resources.
- Explain the role of natural resources in production.
- Describe the flow of natural resources from the environment, through the economy, and ultimately back to the environment.
- Discuss ways to reduce the flow of natural resources in order to reduce wastes.
- Describe the difference between waste flows and pollution.

LESSON DESCRIPTION

Students track the flow of natural resources from the environment, through the economy, and ultimately back to the environment with the use of a materials flow diagram. The law of conservation of matter and energy is vividly demonstrated to help students understand the inevitable flow of wastes that are generated when natural resources are used in production and consumption. Finally, students consider alternatives that can reduce wastes and/or reduce their effect on environmental quality.

TIME REQUIRED

One class period

MATERIALS

A photograph of Earth (as seen from space)
One copy for each student of Activities 1 and 2 (plus Activity 3E)
A listing of natural resources extracted or harvested in your area
Pie tin

Matches
A small, wrapped snack (for example, peanuts, raisins, dried fruit). The wrapper is crucial.
Damp cloth

PROCEDURE

Establishing the Basics

1. To initiate a review of some economic basics, ask: What economic wants do you have?

   Answers would include everything from the basics (food, clothing, shelter) to the less essential (travel, entertainment) to the esoteric (love, security, peace of mind).
2. How can these wants be met or satisfied?

   With goods (apples, water, books, CDs, shirts, pizza, houses, medicine, clean air) and services (education, haircuts, rock concerts, airline service, wilderness areas).
3. What is used to produce these products?

   Productive resources: human (people's mental, physical, and entrepreneurial abilities), capital (tools, machines, factories) and natural (materials and services provided by the natural environment: coal, oil, timber, fish, solar energy, winds, soil, minerals).

Natural Resources Used to Produce Education

4. Explain that education is a service produced using natural resources.
5. Direct each student to write the following categories on a sheet of paper: Plants and Animals; Minerals; Fossil Fuels; Air and Water; Land.
6. Next ask students to look around the room and list all the natural resources (in the appropriate category) that are used to produce their education.

Students may have trouble citing specific natural resources. For example, few probably know that chalk is made from calcium carbonate and clay. What is important here is that they recognize that all the "stuff" around them is produced from extracted or harvested natural resources. Here are some suggestions:

Plants and Animals:
- trees provide the wood for desks, pencils, and doors
- trees also provide the paper for maps, books, and handouts
- plants help provide the oxygen to breathe
- fruits and vegetables provide nourishment for lunch
- cows, chickens, or fish provide meat for lunch

Minerals:
- iron ore, chromium, lead, nickel, copper, and other minerals are used to produce steel alloys and wiring for chairs, building supports, computers, files, and cabinets
- stone, sand, gravel and glass provide structural materials for the school building
- aluminum is used to produce soft drink cans

Fossil Fuels:
- oil, coal, or natural gas produce the energy to heat, cool, and light the room and run the computers and projectors
- petroleum products provide the plastic for many items

Air and Water:
- water is used in the drinking

fountains and restrooms
- air is used for breathing

Land:
- the space occupied by the school, its grounds, and its parking lot

7. **Next ask: Where do these natural resources come from?**
   Here it is enough to emphasize merely that all the resources came from somewhere—a mine, a well, a forest, a river, an ocean, the atmosphere. See the Geography Extension Activity.
8. **Ask: What natural resources are extracted or harvested in our area?**
   Answers will vary. Some prior work by the teacher is necessary here—a listing of natural resource firms in your area helps bring home the fact that natural resources are physically somewhere before they are used in production.

Earth: Our Scarce Natural Resource

9. **Show the class a picture of the Earth (as seen from space). Ask: Is the Earth getting smaller as we use its natural resources? (Of course not!)**
10. **Ask: Has anything made from the Earth's natural resources actually left the planet and its atmosphere?**
    Yes. Lunar vehicles, Alan Shepard's golf ball, the Mars probe, Voyager and Pioneer space crafts, etc.
11. **Ask: Has anything been added?**
    Yes, lunar rocks, solar energy, meteorites.
12. **Ask: If little is added or taken away, what happens to the products we produce once we are done using them? Before the students can respond, say, "I'll show you that they actually do disappear!" Take out of your pocket a small, wrapped snack (such as a bag of peanuts or sunflower seeds). Show it to the class (and if you are a show-person, show them there is nothing up your sleeves!). Unwrap it, placing the wrapper in a pie tin and placing the snack in your mouth. While you are chewing, take a match and carefully set the wrapper on fire (the wrapper should be small and must burn fairly quickly and completely with some dramatic smoke for effect). Have a damp cloth ready to wipe the remaining ashes from the pie tin.**

    Now exclaim, "Ta-da, all gone!" as you show the empty pie tin and your empty mouth. Proclaim that when goods are consumed, the natural resources which make them up are physically destroyed and lost forever.

    The students will generally react by pointing out that you are wrong (or at least a bad magician!). Nothing is gone. The snack is in your stomach and will soon be at the sewage treatment plant, and the wrapper has been transformed into gases and dispersed throughout the room. Note that the students are of course exactly right—nothing really disappears. Materials may be transformed or moved somewhere else, but the basic matter which makes them up never goes away (ignoring nuclear processes). *This is the Law of Conservation of Matter and Energy.*
13. **Now ask: If nothing goes away, why do we need to worry about running out of natural resources? Discuss answers:**
    Materials are combined during production, making them less pure or concentrated. They also become more widely dispersed. For example, suppose a ton of iron ore is removed from a mine. The ore

will eventually be processed into various steel alloys and be used in numerous products. To retrieve all of the original ton of ore would be virtually impossible because of the separation and transportation expenses involved. Other resources are physically and/or chemically changed—the grains and tomatoes used to make a pizza are turned into respirated air and sewage. The problem is perhaps most obvious for energy resources. When a gallon of gasoline is burned it is transformed into several gases (hydrocarbons, nitrogen oxides, carbon monoxide, etc.) which cannot be recaptured to recreate the gasoline. Thus, while the total mass of natural resources does stay essentially the same, the quality of those natural resources (that is, their ability to produce products) is often reduced with their use.

The Flow of Natural Resources Through an Economy

14. **Distribute a copy of Activity 1, and its accompanying worksheet, to each student. This will help students visualize the flow of natural resources through the economy.**
15. **Discuss the flows shown; then ask the students to provide examples of each on the worksheet. Discuss their responses:**

    Natural resources generally enter the economy in the production sector. Note that natural resources play two essential roles in the production process: (1) they are the source of the material or "stuff" things are made from and (2) they are the source of the energy which is required to perform the "work" of production; human and capital resources must have energy inputs to perform production tasks. The products produced are consumed in the consumption sector and are then discarded. This flow of wastes, along with any wastes created in the production sector, is either put directly back into the environment (as are most wastes generated from energy conversion) or it moves on to waste management processes where the wastes are recycled, incinerated, landfilled, or treated in some other way before being placed back into the environment.

    Students should note that the Law of Conservation of Matter and Energy implies that whatever goes into each of the "boxes" shown (production sector, consumption sector, and waste management) must eventually come out. While some things may take longer than others to flow through a "box" (a pizza becomes sewage faster than a building becomes demolition waste), the weight of materials going in will eventually equal the weight of the materials coming out.

    Suggested examples for the worksheet:

    Air and Water: oxygen, groundwater, rain, river flows
    Fossil Fuels: oil, coal, natural gas, methane
    Plants and Animals: timber, crops, whales, tuna, deer
    Minerals: iron, nickel, aluminum, copper, chromium, gold, silver
    Wastes from Energy Conversion: carbon dioxide (greenhouse gas), carbon monoxide, sulfur dioxide

(component of acid rain), ash, nitrogen oxides (component of smog), radioactive wastes (from nuclear processes based on uranium or plutonium inputs)

Products: food products, wood products, metal products, plastics (from petroleum), rubber products, fiber products, paper, structural products, glass products

Wastes from Production: food wastes (potato skins), slag, tailings, sawdust, scrap, rubbish, waste paper, discarded machines, demolition materials, solvents, cleaners

Wastes from Consumption: junk autos, discarded appliances, sewage, garbage, cans, plastic containers

Recycled Materials: aluminum, paper pulp, scrap metals, plastics

Land Disposal: wastes placed in landfills, salt mines, caves

Water Disposal: treated sewage into waterways

Air Disposal: incineration creates essentially the same flows listed above for wastes from energy conversion

16. **You might conclude this step by noting that, by weight, fossil fuels represent about half of the total natural resource inputs (excluding air and water) into the economy (and most of this is quickly released back into the environment as the wastes from energy conversion). Minerals account for another fourth and plants and animals the remaining fourth. The fact that none of these wastes "goes away" is at the root of many environmental problems (see Lesson 1).**

The "Four Rs": Reduce, Reuse, Recycle, and Refine

17. **Distribute Activity 2 to each student. It lists the four general ways that have been suggested to reduce the flow of natural resources through the economy (and thus reduce the inevitable wastes). Ask students to suggest examples of each.**

Answers will vary; here are some suggestions:

Reduce: turn down thermostats, use less packaging, grow your own vegetables, take shorter showers, become a less "materialistic" society

Reuse: use fewer disposable products, produce more durable products, send clothes to charitable organizations, find other uses for goods

Recycle: collect and reprocess glass, aluminum, scrap metal, plastics, paper, and other materials

Refine: design processes which use more of each tree that is cut, cars that get more miles per gallon, better insulated buildings, more energy-efficient products, smaller products.

18. **Ask: Although producing electricity from uranium or plutonium involves a lesser natural resource flow than producing it from coal, does that alone make nuclear power generation a better choice? Discuss responses:**

Students should realize that all wastes are not the same. A pound of radioactive wastes is likely to have a different impact on environmental quality than a pound of carbon dioxide emissions. Thus, while reductions in natural resource inputs will lead to reductions in the amount of wastes generated (remember the Law of

Conservation of Matter and Energy), these reductions do not all have the same effect on improving environmental quality.

CLOSURE

Note that many economists define pollution as a loss of the product environmental quality (see Lesson One). Thus, wastes cause pollution only to the extent that they lead to lower levels of environmental quality. The purpose of waste management is thus not so much to reduce wastes, but to reduce pollution (the impact of wastes). Reducing natural resource inputs is just one of many options.

EXTENSION ACTIVITIES

Geography

19. Ask students to divide up into groups and write to (or if possible, visit) a local manufacturing or processing plant. Tell the students they are to investigate the quantity and kinds of raw materials and energy resources used in the plant, and where these inputs came from. Ask the students to attempt to track these natural resources back to their geographic origins through letters to the plant's suppliers. For example, the electricity used might be tracked back to a coal mine in southern Montana, while paper might be tracked back to a forest in northeastern Minnesota. Assign the groups to report their findings to the rest of the class.
20. Assign students to research the natural resources extracted or harvested in their state and produce a color-coded map for each of the general natural resource categories: fossil fuels, agricultural products, and minerals. They could in addition investigate to see what goods and services are ultimately produced with these resources.

Family Studies

21. Most wastes generated from consumption activities are in the form of sewage (dirty water, garbage disposal wastes, human wastes), emissions into the air (fuels burned in fireplaces, backyard barbeques, and vehicles) and solid wastes (garbage or trash). Assign students to conduct a study of their own family's garbage and compare its composition to a national average.
22. To begin, students should sort their family garbage for a week into a box for each major type of waste: paper, yard wastes, metals, glass, plastics, food wastes, and other wastes (rubber, textiles, wood, etc.). You might also ask them to record the wants or needs satisfied by the original products.
23. At the end of the week, students should determine the weight of the contents of each box and what percentage this is of the total weight collected. Compare these individual results (and the class aggregate results) to those below:

WHAT'S IN OUR GARBAGE?

Amount (1988 data)	Millions of Tons	%
Paper and paperboard	71.8	40.0
Glass	12.5	7.0
Metals	15.3	8.5
Plastics	14.4	8.0
Food wastes	13.2	7.4
Yard wastes	31.6	17.6
Other	20.6	11.5
Total	179.4	100.0

Source: Executive Summary, Characteristics of Municipal Solid Waste in the U.S., 1990 Update, June 1990, EPA Office of Solid Waste.

24. Discuss any similarities or differences. Students also should discuss their results with their families.

Environmental Science

25. Distribute Activity 3E; have students read it; then discuss it with them. Note that hazardous wastes are created both when goods and services are produced and after they are used.
26. Assign a different household hazardous waste to each student in the class (some common ones are listed below) and assign students to research and answer the questions on Activity 3E. These may then be compiled into a "Household Hazardous Waste" handbook for the school library. The following list suggests some possibilities:

COMMON HOUSEHOLD HAZARDOUS WASTES
(*denotes solvent-based):

antifreeze	battery acid
contact cement	driveway sealer
lighter fluid	paint thinner
turpentine	varnish
oven cleaner	hair remover
furniture polish	shoe polish
cleaners*	car wax*
brake fluid	acetone
gasoline	shellac
paint	stain
nail polish	pesticide
fungicide	mothballs
rat poison	weed killer
metal polish*	glue*

Science

27. Discuss the Law of Conservation of Matter and Energy.
28. Under close supervision, direct students to run an experiment which tests the law. For example, burn paper or melt an ice cube in a closed container and weigh the container both before and after. While the law holds for most processes, you might note that minuscule amounts of matter are transformed (and destroyed) into energy by nuclear processes.

Math

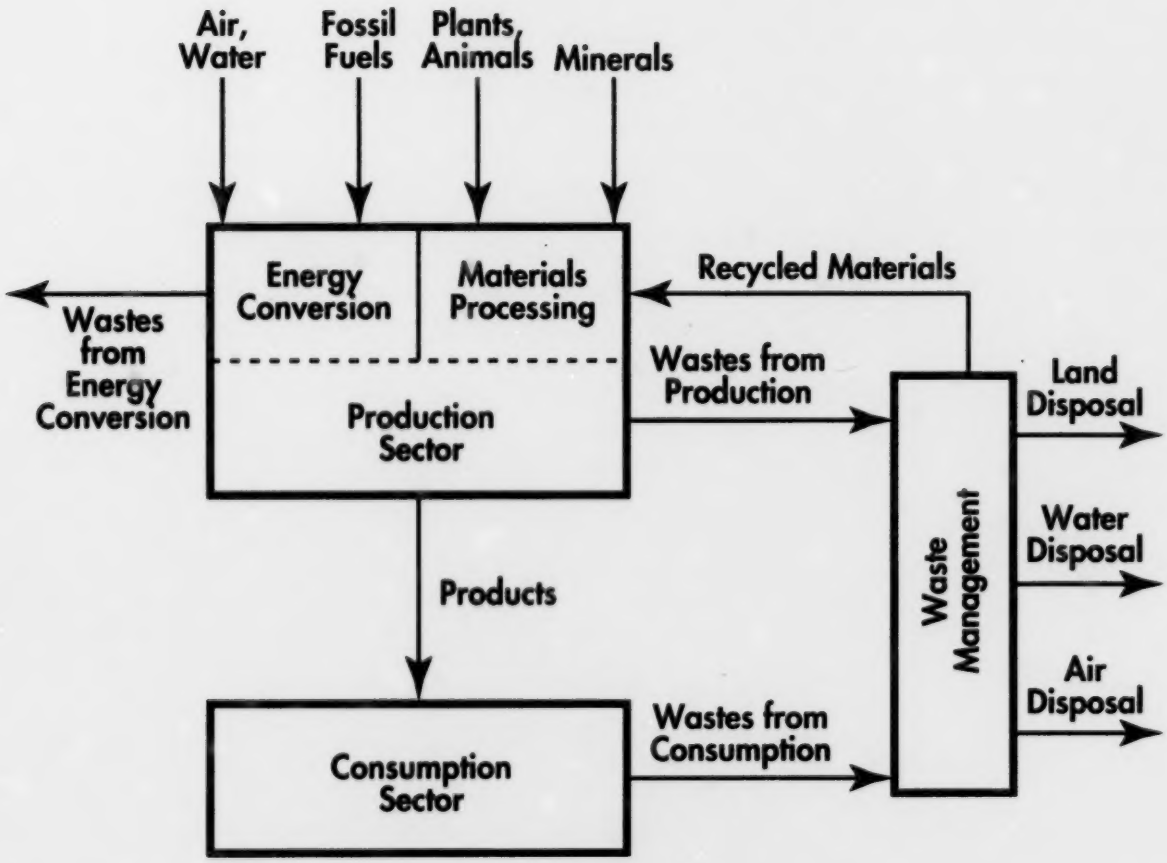
29. Note that the total volume of municipal solid wastes (MSW) placed in landfills in the United States was about 270 million cubic yards in 1991.
30. Ask students to suggest creative ways to describe how much "room" is needed to accommodate these wastes. Some examples might include:
    a. It would fill our school building X times.
    b. It would fill a sphere with a diameter of X feet.
    c. It would cover X square feet of land, Y inches deep.

Community

31. Invite a speaker from your local water treatment, sanitary landfill, or incinerator facility to visit your class and discuss how wastes are handled in your community.
32. If possible, arrange a field trip to one or more of these facilities.

ACTIVITY 1

THE FLOW OF NATURAL RESOURCES THROUGH THE ECONOMY



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 1 WORKSHEET

Give examples of each of the flows illustrated in Lesson 2, Activity 1.

Air, water:

Fossil Fuels:

Plants, Animals:

Minerals:

Wastes from Energy Conversion:

Wastes from Production:

Goods:

Wastes from Consumption:

Recycling:

Land Disposal:

Water Disposal:

Air Disposal:

ACTIVITY 2

THE "FOUR Rs"

The "Four Rs" suggest general ways to reduce the flow of natural resources through an economy. Give some specific examples of each of the following:

REDUCE
Use goods which require fewer natural resource inputs

Examples:

RECYCLE
Collect materials and use them to produce new goods

Examples:

REUSE
Use goods more than once or in new ways

Examples:

REFINE
Develop production processes which generate less material waste and higher energy efficiencies

Examples:

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3E

HAZARDOUS WASTES

Directions: Read the following information about hazardous waste. Be prepared to discuss it.

The U.S. Environmental Protection Agency defines hazardous waste as any discarded chemical that is flammable (waste oils, organic solvents), unstable enough to explode or emit toxic fumes (cynacide solvents), corrosive to metals or human tissue (strong acids, strong bases), or toxic if improperly released into the environment (DDT, dioxins, heavy metals). The EPA focuses on chemicals discarded by major producers, but one might also include wastes with these characteristics discarded by households, chemicals that cause cancer or gene mutations, radioactive wastes, municipal incinerator ash, cement kiln dust, and oil and gas drilling wastes. In general, if they are released untreated, these wastes have very harmful effects on human and animal health, and they can not be transformed naturally by the environment into less harmful substances.

Even using the EPA's somewhat limited definition, the amount of hazardous wastes produced each year in the United States, stacked in 55-gallon drums, would stretch to the moon! Over 90% of this waste by weight is generated by the chemical, petroleum-refining, and metal-processing industries. Most of it (about 95%) is treated or stored on the production site; the remainder is handled primarily by special landfills. In the past these wastes were often dumped indiscriminately into waterways or buried. While the number of such dump sites has been estimated to be as high as 425,000, fewer than 1500 are on the EPA's "Superfund" clean-up list and by 1991 only 64 had been declared clean (at a cost of about $7 billion).

The National Academy of Sciences has developed a set of steps for dealing with hazardous waste. First, prevent it entirely by using alternative production technologies or through recycling and reusing the wastes. Second, convert it into less hazardous or nonhazardous substances through incineration or other treatment (thermal, biological, physical, or chemical). Finally, as a last resort, put it in permanent storage in secured landfills or underground vaults (including salt formations). Currently, actual disposal practices follow just the opposite order in the United States, where only about 5% of hazardous waste is recycled or reused, 5% is incinerated or used in industrial boilers, 22% is treated in some manner and discharged into streams and sewers, and 68% is disposed of in pits, ponds, landfills, or deep wells, where long-term groundwater safety is put into question.

In 1976 Congress passed the Resource Conservation and Recovery Act. This law requires the EPA to identify wastes and set standards for their management. It also requires hazardous-waste producers who are granted disposal permits to track their wastes from production to disposal. Environmentalists have argued that the law is not far-reaching enough (e.g., many hazardous wastes are not included) and is also too difficult to effectively enforce—especially if fines are too low. At least the law recognizes the link between the production of certain goods and the generation of hazardous wastes.

*From **Economics and the Environment;** ©National Council on Economic Education, New York, NY*

ACTIVITY 3E WORKSHEET

HOUSEHOLD HAZARDOUS WASTE REPORT

1. What household waste are you studying?

2. What economic want did the original product(s) provide?

3. What natural resources were used to produce this product?

4. What is the required or recommended way or procedure to dispose of this waste in your community?

5. What are the potential impacts on the environment if this product is improperly disposed?

6. Are there alternative products or services that could have met the economic want satisfied by this product?

7. What wastes would these alternative products have generated?

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

UNIT 2

GETTING THE MOST VALUE FROM NATURAL RESOURCES

WHAT ARE SPOTTED OWLS, TIMBER PRODUCTS, AND MAGICAL STONES REALLY WORTH?

INTRODUCTION

What makes a CD player or a spotted owl valuable? Is it something intrinsic in the CD player or the owl, or is the value based somehow on how the product or bird is produced? Generally, economists say "no" to both possibilities. The value of a product is determined by its ability to satisfy the economic wants of those who consume or use it. A product's economic value is measured by the maximum amount someone is willing and able to pay for it. In this lesson students look at the difference between the value of a product and its market price. They discover that although many products provided by natural resources of the environment have no prices, they still have great economic value.

ECONOMIC CONCEPTS

Value/Economic Value
Demand
Price/Market Price

ENVIRONMENTAL CONCEPTS

Habitat

OBJECTIVES

- Define economic value.
- Explain how economic value is measured.
- Explain why people value products differently.
- Describe the difference between the value of a product and its market price.
- Explain how a product's demand curve provides information about the product's value.
- Explain why even unmarketed, unpriced products (such as those provided directly by the natural resources of the environment) can still have economic value.

LESSON DESCRIPTION

By means of the following activities students reveal their own economic valuations and discover how these are observed and measured. The lesson starts with a familiar commodity, a CD player, and then moves on to analyze the value of a magical stone. The culminating application applies the concepts to the valuation of spotted owls and timber products.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-13
Day 2: Steps 14-closure, plus Extension Activities

MATERIALS

An unusual stone in an ornate box or small safe
One copy for each student of Activities 1, 2, and 3 (plus Activities 4E and 5E)

PROCEDURE

How valuable is a CD player to you?

1. Tell the students you have a new CD player that you would like to give away to somebody in the class. Ask who would like to have it; call for a show of hands. Count hands and the record the number on the board (it probably will be everyone in the room).
2. Follow up by asking the students why they want the CD player.
   It satisfies a desire for entertainment they probably have.

3. Next ask how many students would like the CD player if, in order to get it, they were required to stay an extra hour at school each month. Again record the response.
4. Continue adding conditions and recording the responses as shown below (feel free to add some of your own):

Conditions	Number of Students Who Would Take the CD Player
1. No conditions	XX
2. Extra hour at school each month	XX
3. #2-plus no pizza for a month	XX
4. #3 plus no television for a month	XX
5. #4 plus no dates for a month	XX
6. #5 plus a 10-page research paper	XX
7. #6 plus no use of a car for a month	XX
8. #7 plus etc.	XX

As the conditions increase (notice that they are cumulative), fewer and fewer students will be willing to take the CD player.

Note that economists define the economic value of a commodity by its ability to satisfy the desires of individuals. This is measured by the extent to which an individual is willing to sacrifice other satisfaction-generating products (here: pizza, TV time, dating time, leisure time, etc.) to get it. The more a person is willing to sacrifice, the more valuable the product is said to be to that person.

5. Ask: Why isn't everyone willing and able to sacrifice the same amount for a CD player?

   People have different economic wants: some might feel they absolutely must have a player to survive, others may not care much for music at all. They also will view the products being sacrificed differently: for some giving up television may be a very large sacrifice, for others it may not be. Value, like beauty, is in the eyes of the beholder!

Measuring Value in Terms of Money

6. Ask each student to write a list of the products or product he or she would buy if somebody suddenly gave him or her $100 to spend in any way whatsoever.
7. Point out that the true economic value to each person of $100 is the value each would receive from the items on this list. If a person says the maximum amount she is willing and able to pay for a product is $100, she is really saying that that product is worth as much to her as all the items on her "$100-list." Thus, instead of measuring value in terms of the actual products sacrificed, economists often use the more convenient monetary measure—the maximum amount the person is willing and able to pay.

Value and the Smart Stone

8. Show the students an unusual stone you have brought to class enclosed in an ornate box or small safe (to suggest that the stone is very special in some way).
9. Relate the following story about the stone:

   "Stones such as this one are found only in a remote part of central Australia. Their geological history is a mystery—perhaps they were part of a meteorite. What is known is that holding a stone of this size tightly in one's hand for an hour will double the holder's IQ for one week. Unfortunately, each of these "smart stones" can produce this effect only once, and each person can experience this effect only once (that is, even other "unused" stones cannot repeat

the effect for a given person). This particular smart stone has yet to be used. Its effect could be very useful to you as a student around finals time or at some other time when you need a little extra boost in your thinking abilities."

10. Ask each student to secretly write down on a blank sheet of paper the maximum he or she would be willing and able to pay for such a stone if it were available at an auction. Ask all the students to seriously consider how the stone might benefit them if all you have related were in fact true. Remind them that they must not only be willing to pay the amount they write but also able to pay it.
11. Collect the bids, list them from highest to lowest on the board (for example: $50, $25, $20, $20, $10, $5, $5, $5, $0), and then have each student record the bids on Lesson 3, Activity 1. Note that each bid represents someone's personal economic valuation of a smart stone.
12. Allow students 15 minutes to complete the Activity questions individually or cooperatively. Here are the suggested answers:
    a. Read values from the "value of stone" column.
    b. The total value of a given number is the sum of the individual values. For example, the total value of four stones is the sum of the value of the 1st, 2nd, 3rd, and 4th.
    c. All those which have a higher value than the price given.
    d. They would have been higher (students would have been more able to pay and probably, therefore, more willing and able to pay.)
    e. They would have been lower (students would have been less willing to pay since the stone does not meet their need or want for increased intelligence as well as before).
13. Next, discuss their answers and lead discussion to make the following points:
    a. *The value of each additional unit of a product tends to decline.*
    All the stones do not have the same value: the first is more valuable than the tenth which is more valuable than the twentieth (based on question a). This is because as society or an individual gets more of any product, the want or need being satisfied by that product decreases. This may be illustrated by asking students the value to them of the first piece of pizza they eat versus the third or tenth piece (by the time they have eaten nine pieces, their hunger is probably satisfied; the tenth piece thus would do little to provide any extra satisfaction and is not very valuable to them).
    b. *More of a product generates greater total value.*
    The total value of a given number of stones is the sum of the values of each (based on question b). For example, if the first stone has a value of $50, the second $20, and the third $10, the total value of three stones would be $80.
    c. *The value of a product is not equal to its price.*
    People will buy a stone only if its price is less than (or equal to) the value they personally attribute to it (based on question c). Note the difference between value and price: value is how much someone is willing and able to pay for something; price is the amount they actually have to pay to get it.

d. *Changes in people's income or tastes and preferences will change the value they attribute to a product.* Note that changes in income alter a person's *ability* to pay, while changes in preference alter a person's *willingness* to pay (based on questions d and e).

Value and Demand

14. Distribute Activity 2 (or plot the actual information from Activity 1). This activity illustrates the dual role of a demand curve: (1) given a price, this curve shows the quantity of stones that would be purchased (find the price on the vertical axis, read over to the curve and then down to the horizontal axis); or (2) it shows the value of the n-th stone (find a particular amount of stones along the horizontal axis such as five, read up to the curve and then over to the vertical axis; the amount given is the value of the fifth stone—in this case, $4.00). The demand curve may also be used to find the total value of any given number of stones (simply add up the individual values or find the area under the curve up to the quantity in question).
15. Ask the students to answer the questions after discussing the points above. Answers follow:
    a. 2; 5; 10
    b. $8.00; $4.00; $1.50
    c. $10.00 + $8.00 + $6.00 = $24.00
    $10.00 + $8.00 + $6.00 + $5.00 + $4.00 = $33.00
    $33.00 (for the first five) + $3.00 + $2.50 + $2.00 = $40.50
    d. As price rises the quantity demanded falls. You might note that this relationship is often referred to as the "law of demand."
    e. The value of each additional stone tends to fall (the first units provide more satisfaction than do later units).
    f. Society gets more value as it gets more stones.

The Case of the Spotted Owl

16. Distribute Lesson 3, Activity 3. Ask the students to read the article. Discuss the competing uses of the forest which generate value (timber harvesting and habitat for the spotted owl).
17. Ask if these are both valuable uses.
    Yes. Both satisfy the desires of individuals; people enjoy the homes, furniture, and newspapers the timber makes possible and people enjoy viewing owls or just knowing their habitat is being preserved for future generations.
18. Draw two similar demand curves on the board. Put *number of acres devoted to timber harvesting* on the horizontal axis of one and *number of acres devoted to owl habitat* on the other. Note that, because both uses generate value, as in the case of the stones, demand curves like these may be drawn.
19. Ask: How well are the values indicated by these curves reflected in markets?
    Because timber is traded in markets, its value to users is reflected by the prices they are willing and able to pay. The market for "owl preservation" on the other hand is not well-developed. One may value such a product, but there is no easy place to go or call to express one's willingness and ability to pay for it; it is not on the shelf of any store!
20. Given a fixed amount of acres, discuss how the value society receives

from these two uses is changed as the number of acres devoted to one of them is increased.

As more acres are devoted to habitat, the value from habitat uses grows while the value from timber uses falls. Similarly, as more acres are devoted to timber uses, the value from habitat use falls and the value from timber uses rises. This is illustrated by showing how the area under each demand curve up to the quantity in question changes as more or fewer acres are devoted to a particular use.

21. Ask students to suggest a rule for deciding how much to devote to each use.

They will likely come up with a rule very much like the rule of allocative efficiency (see Lesson 5). This rule essentially says it is efficient to divide the land between the two uses such that the total value generated from both uses is maximized.

CLOSURE

Note that since many of the products provided by natural resources of the environment are provided directly to people (clean air and water, ultra-violet ray protection, scenic vistas, lakes to swim in, trees for shade and carbon dioxide absorption—see Lesson 1), they do not pass through markets. Thus, they have no prices. But they are still valuable, since they satisfy a want or need that people are willing and able to pay for. In deciding how best to use these resources, it is therefore important that we concentrate on the value of the products they produce and not the prices.

EXTENSION ACTIVITIES

Math

22. Distribute Activity 4E. Explain that the graph shows the linear relationship between the price of a product and the quantity demanded by consumers. Note the definitions of total expenditures, consumer surplus, and total value as described on the activity sheet.
23. Direct the students to complete the activity. Answers follow:
    a. TE = P x Q, the area of a rectangle
    CS = (1/2) x Q x (P^d-P), the area of a triangle
    TV = (1/2) x Q x (P^d+P); or the sum of TE and CS
    b. At \$14: TE = \$42, CS = \$9, TV = \$51
    At \$8: TE = \$48, CS = \$36, TV = \$84
    At \$4: TE = \$32, CS = \$64, TV = \$96.

Science

24. Discuss the role of plants in the carbon cycle and why this cycle is valuable to individuals. In particular, discuss theories which link excess carbon dioxide accumulation in the atmosphere to global warming and the potential consequences to society (coastal flooding, desert expansion, etc.).
25. Ask students how much they would be willing and able to pay to avoid these potential damages.

Social Studies

26. Discuss the factors influence how we personally value products. A partial list might include advertising and the media, your culture, your friends and family, the education and information we receive, etc.

27. Have students give examples of how these factors affect the value they assign to various commodities such as deodorants, whales, CDs, clean air, and broccoli.

Economics

28. Extend your analysis of Activity 2. Tell the class to suppose that the price of a stone is $5.00. Ask:
    a. How many stones would be purchased? (4)
    b. How much would be spent (total expenditure) on these four stones? ($5.00 x 4 = $20.00)
    c. What is the total value received from the four stones? ($10.00 + $8.00 + $6.00 + $5.00 = $29.00)

    Note that the difference, $9.00, is consumer surplus, or value received in excess of the amount paid. The $20.00 may be thought of as "realized" value or value which may be measured by anglyzing market transactions. The consumer surplus may similarly be thought of as "unrealized" value, or value which is not being captured in the market transaction. Ask students also to consider other prices and calculate the total expenditures, consumer surplus, and total value (the sum of the first two). Note that the total expenditure on any product in general is less than the value people are receiving from it.
29. Economists define the value of a product by its ability to satisfy the desires of individuals. Ask students working in groups to come up with alternative measures of the value of a product. Prod their thinking by asking: Should the desires of "other" species be considered? Do some products have some kind of intrinsic value of their own? If so, what is that value based on?
30. Economists often use gross domestic product (GDP) as a measure of the value of a country's output. Assign students to investigate what GDP measures (the market value or expenditures made on all final goods and services produced) and then ask: is this a good measure of the value we are generating from our resources? A suggested answer follows:

    Probably not, since it ignores consumer surplus and all those products which do not have market prices but are clearly valuable—clean air, spotted owls, beautiful sunsets, etc.

Government/Law

31. Show a transparency of Activity 5E. A recent law in the state of Minnesota has set "values" for the state's fish and game populations as shown on the handout.
32. Prompt students to discuss whether they think the values are too high or too low for the different species.
33. Next ask them to concentrate on the $4,000 value for a bald eagle. Suppose there were only one pair of bald eagles left in the world. Ask the students if they think $4,000 is proper restitution for killing one of these eagles.
34. Now suppose eagles were as plentiful as mosquitos in Minnesota. Ask again if $4,000 sounds like reasonable restitution. Note, as was demonstrated by the activities above, that the value of an eagle (like the value of a stone) depends on which one it is—the first or the one-millionth; there is no single value for all eagles.

ACTIVITY 1

THE VALUE OF SMART STONES

Stone	Value of Stone*
1st	_____
2nd	_____
3rd	_____
4th	_____
5th	_____
6th	_____
7th	_____
8th	_____
9th	_____
10th	_____
11th	_____
12th	_____
13th	_____
14th	_____
15th	_____
16th	_____
17th	_____
18th	_____
19th	_____
20th	_____
21st	_____
22nd	_____
23rd	_____
24th	_____
25th	_____
26th	_____
27th	_____
28th	_____
29th	_____
30th	_____
31st	_____
32nd	_____
33rd	_____
34th	_____
35th	_____

a. What is the economic value of the
1st stone? _____
2nd stone? _____
5th stone? _____
10th stone? _____
15th stone? _____
last stone? _____

b. What is the total value of
2 stones? _____
4 stones? _____
7 stones? _____
10 stones? _____
15 stones? _____

c. How many stones would be purchased if the price of each stone was
$100.00? _____
$ 25.00? _____
$ 5.00? _____
$ 1.00? _____
$ 0.10? _____

d. Suppose that at the start of class everyone had been given $50.00. How would this probably have changed the amount each person wrote down?

e. Suppose everyone had been told the stone increases your IQ only by 25%. How would this information probably have changed the amount each person wrote down?

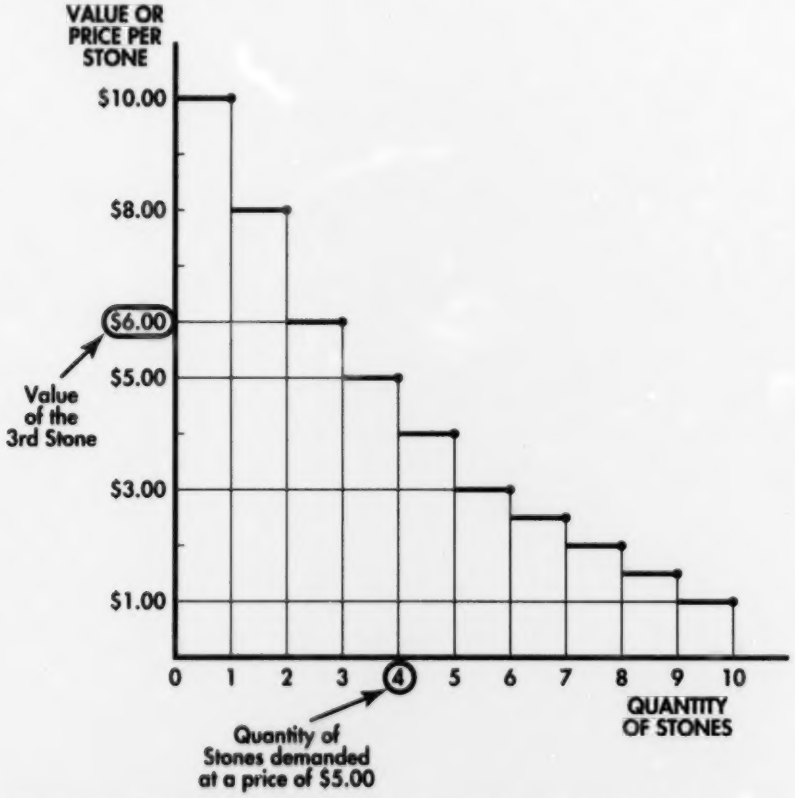
* Individual responses to: "What is the maximum you would be willing and able to pay for a stone?"

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

VALUE AND THE DEMAND CURVE

The curve below is based on plotting bids like those in Activity 1 from the highest to the lowest. This is the demand curve for stones; it shows three things, as illustrated below: (1) the quantity of stones demanded at each price, (2) the value of each additional stone, and (3) the total value of a given number of stones (sum of the value of each of them—shown by the area under the demand curve up to the number given). Based on this, complete the questions below.



a. How many stones would be demanded at a price of $8.00? ____
... $4.00? ____
... $1.00? ____

b. What is the value of the 2nd stone? _____
... 5th stone? _____
... 9th stone? _____

c. What is the total value of 3 stones? _____
... 5 stones? _____
... 8 stones? _____

d. What general conclusion can you draw from (a)?

e. What general conclusion can you draw from (b)?

f. What general conclusion can you draw from (c)?

ACTIVITY 3

Endangered Species, Endangered Jobs

PROTECTING spotted owls and logging jobs at the same time is proving difficult.

In the 14 months since the northern spotted owl was placed on the endangered species list, 71 primary manufacturing plants have closed on Oregon, Washington, Idaho and California. These sawmills and plywood and veneer plants employed 6,371 workers. The shutdowns threaten the survival of many towns.

"We haven't seen the end yet," says Paul Ehinger, an industry consultant in Eugene, Ore. His surveys show the vast majority of losses stemmed directly from limitations on federal timber harvests. He says the restraints won't have full effect until 1992, when timber now under contract will have been harvested.

Spotted owls and other rare species are protected for ecological balance and scientific insights. A federal study found that the remaining spotted owls need at least 8.4 million acres of old-growth habitat to survive.

Most companies rely on public lands for the bulk of their timber supplies. But in the ancient for-ests of the Pacific Northwest, where a single tree can yield enough wood for four houses, new protection for spotted owls shields millions of acres of spruce, fir, pine and hemlock. In addition, revised Forest Service rules are generally discouraging clear-cut logging practices in more areas, and federal bans on log exports have spread to many state-owned lands.

As a result, volumes of timber under contract are extremely low. In coastal regions of Oregon, Washington and California, for example, the total volume under contract on federal lands is 3.53 billion board feet, down from 10.74 billion in 1986. Wiliamette Industries, Portland, Ore., now counts on private lands for 62% of its timber, compared with 50% two years ago.

Reprinted by permission of The Wall Street Journal.
© 1991 Dow Jones & Co., Inc. All rights reserved worldwide.

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

ACTIVITY 4E

TOTAL VALUE = TOTAL EXPENDITURES + CONSUMER SURPLUS

The total value received by consumers from a product is based on the amount they are willing and able to pay for it. This is shown by the demand curve. The amount they actually pay is called the total expenditure (and is based on the price in the market). The difference between the two (what consumers are willing and able to pay and what they actually pay) is called consumer surplus. These are illustrated below. At a price of P consumers buy Q units of this product. Their total expenditures (TE) are shown by area A. The consumer surplus (CS) they receive is shown by area B. The total value (TV) they receive is simply the sum of area A and area B. Given this, do the following:

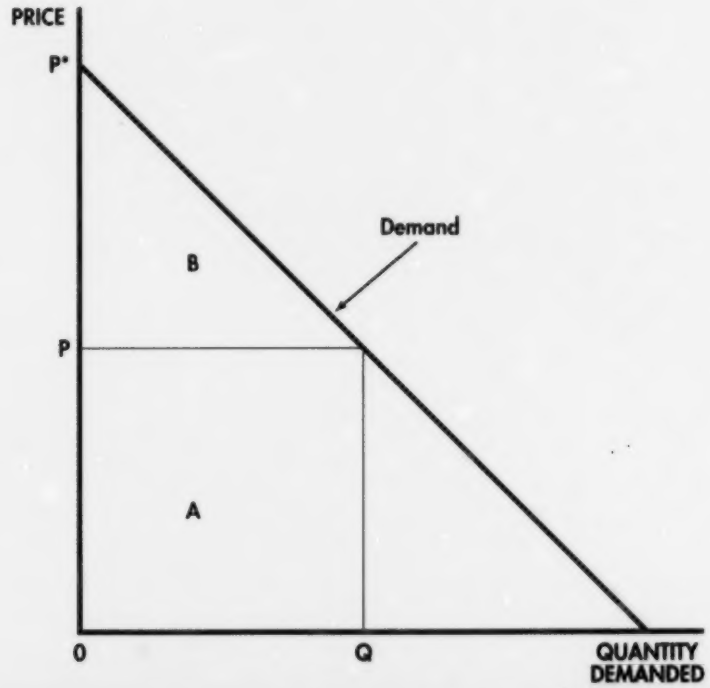
a. Assuming the demand curve is linear, derive algebraic expressions for TE, CS, and TV in terms of P, Q, and P*.
TE =

CS =

TV =

b. Suppose the specific equation of the demand curve shown below is P = 20–2Q. Find the values of each of the three concepts in (a) for the following prices: $14, $8, $4.

At $14:	At $8:	At $4:
TE =	TE =	TE =
CS =	CS =	CS =
TV =	TV =	TV =



ACTIVITY 5E

SETTING WILDLIFE VALUES

Restitution

New law sets values for fish and game

People who unlawfully take game and fish should pay more than a fine. They should, in fact, make restitution, which is a payment to restore lost values to the people of Minnesota as opposed to a criminal penalty designed to punish the violator.

A law to this effect was passed by the Minnesota Legislature in 1989. During the past two years the exact details of this law have been studied and agreed upon. In the future, poachers may face not only fines, but restitution payments as well.

$ 500

$ 50

$ 5

Some base values

Crappie	$5
Perch	5
Rabbit	20
Walleye	*30
Northern pike	*30
Mink	30
Raccoon	30
Geese	50
Ducks (except canvasback)	50
Grouse	50
Pheasant	50
Partridge	50
Otter	100
Canvasback duck	200
Tundra swan	200
Wild turkey	400
Black bear	400
Prairie chicken	500
Deer (non-trophy)	500
Muskies	up to 1,000
Moose	1,000
Trumpeter swan	3,000
Bald eagle	4,000
Endangered birds	4,000

*values increase with size

DNR Graphic

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

THE COST OF POLLUTION: WHAT IS BEING GIVEN UP?

INTRODUCTION

What is pollution? Economists define pollution as a loss of environmental quality. The cost of pollution is thus the value of the environmental quality lost. This cost may be prevented or reduced through waste management activities and/or preservation efforts. Unfortunately, these activities often have costs of their own. In this lesson, students look at costs in general and costs associated with pollution and pollution prevention in particular.

ECONOMIC CONCEPTS

Costs/Opportunity Costs
Production Possibilities Curve
Value
Demand
Supply

ENVIRONMENTAL CONCEPTS

Pollution
Pollution Costs
Pollution Prevention Costs
Biochemical Oxygen Demand (BOD)
Global Warming
Greenhouse Gases

OBJECTIVES

- Define opportunity costs.
- Evaluate costs in terms of forgone value.
- Describe pollution in terms of lost environmental quality.
- Define pollution costs as the value of the environmental quality which is lost or given up.
- Explain why preventing pollution also involves costs.

LESSON DESCRIPTION

The activities illustrate the nature of the costs associated with pollution and pollution prevention. Students focus on the fact that something valuable is always given up when a choice is made. In the culminating application, students consider the costs associated with global warming.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-10
Day 2: Steps 11-23 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 2, 3, 4, and 5

PROCEDURE

Opportunity Cost: The Basics

1. Relate the following story to your students: "The other day Mindy went to the mall with $10. With this sum of money Mindy could have bought a shirt (which she valued at $18 — the maximum amount she was willing and able to pay for it), a pizza (which she valued at $12), a stuffed toy (which she valued at $1), or a book on ways to improve the environment. All the items were priced at $10. She decided to buy the book."
2. Ask: What was the real cost of this book to Mindy?

   Students will want to say $10 — the book's price — but the true or real cost is the lost opportunity to enjoy the next most valuable alternative that had to be given up. Economists refer to this cost as the opportunity cost. In this case the opportunity cost of purchasing the book was the shirt that Mindy could also have purchased. Since the value of the shirt to Mindy is $18, that is the

opportunity cost of the book. You might note that the value of the book to Mindy at that time must have been even greater than $18 or she would not have chosen it.

Deriving Costs as Lost Value

3. Distribute Activity 1. Describe the nature of the production possibilities curve shown. Here are some points to raise:
   This particular curve is developed in Lesson 1. It shows the various combinations of wilderness and minerals that might possibly be produced with six million acres of land (those combinations inside or on the curve). Along the curve, more mineral production implies less wilderness and vice versa.
4. Next describe how the demand curve shows the value of each ton of minerals. For example, the value of the 20th ton of minerals is $9 million, the value of the 12th is $17 million, etc. This concept is developed in Lesson 3.
5. Tell students that they are going to derive the cost of the land used in providing acres of wilderness from the information given.
6. Ask the class to begin by considering this society's options, starting with devoting none of its land to wilderness preservation and all to mineral production. Students should identify this point on the production possibilities curve [(0,24)].
7. Ask the following questions:
   a. What must be given up to preserve the first million acres of wilderness?
      The production possibilities curve shows one ton of minerals — the 24th.
   b. What is the value of these minerals?
      The demand curve shows the value of the 24th ton of minerals to be $5 million.
   c. What then is the cost of the first million acres of wilderness?
      $5 million — the value of the forgone opportunity to produce the 24th ton of minerals.
   d. What must be given up to preserve the second million acres of wilderness?
      Two more tons of minerals — the 23rd and 22nd.
   e. What is the value of these tons?
      $6 million and $7 million, respectively.
   f. What then is the cost of the second million acres of wilderness?
      $13 million.
   g. Repeat for the 3rd and 4th million acres of wilderness.
      Costs are $27 million and $50 million, respectively.
8. Direct students to plot these points on their graph and connect them with a smooth curve. Note that this curve shows the cost of the land needed to provide each additional million acres of wilderness. Lead class discussion to make the following points:
   a. *The cost of providing each additional unit of a product tends to rise.*
      Note that the cost of getting *more* of one product (here, wilderness preserves) generally rises for two reasons: (1) more of other products must be given up to get it (as is illustrated by the curvature of the production possibilities curve) and (2) the value of what is being given up rises (as is illustrated by a downward-sloping demand curve).

b. *The total cost of providing a given amount of a product is the sum of the cost of each unit.*

For example, the total cost of preserving 3 million acres of wilderness is the cost of the 1st ($5 million), plus the cost of the second ($13 million), plus the cost of the 3rd ($27 million), or $45 million.

Costs and Supply

9. Distribute Activity 2. Allow students 15 minutes to complete it.
10. Discuss these points: This activity illustrates the dual role of a supply curve: (1) given a price, this curve shows the quantity of stones that would be offered for sale (find the price on the vertical axis; read over to the curve and then down to the horizontal axis); or (2) it shows the cost of the n-th stone (find a particular quantity of stones along the horizontal axis, such as seven; read up to the curve and then over to the vertical axis: the amount given is the cost of providing or producing the seventh stone — in this case, $7.00. This curve may also be used to find the total cost of any given number of stones (add up the individual values or find the area under the curve up to the quantity in question).
    a. $3.00; $6.00; $10.00
    b. $4.50 ($2.00 + $2.50)
    $16.50 ($2.00 + $2.50 + $3.00 + $4.00 + $5.00)
    $29.50 ($16.50, for the first five, + $6.00 + $7.00)
    c. 9; 5; 1
    d. The cost of producing each additional stone tends to rise.
    e. The more stones produced, the higher the cost — "there is no such thing as a free lunch."
    f. As price falls so does the quantity supplied. Producers will produce only those units whose costs are less than or equal to the cost of producing them. As price falls, there are stones whose cost is less than the price and so fewer are supplied.

Pollution and Pollution Costs

11. Pollution is defined by economists as a loss of environmental quality (described in Lesson One as the quantity and quality of life-support and amenity products provided directly to people by the natural resources of the environment). The cost of pollution to society is thus the forgone value of environmental quality.
12. Ask students to suggest some examples of pollution and describe the value which is lost in each case. Some possibilities include the following:
    - lost good health due to dirty air or increased ultra-violet rays
    - lost swimming enjoyment due to wastes in a lake or river
    - smaller crop yields and slower forest growth due to sulfur emissions
    - lost wildlife habitat due to land development and/or resource extraction
    - lost drinking water due to contaminated groundwater supplies
13. Pollution costs may also appear in the form of avoidance costs. Pose the following to the students: Suppose you had a job working in a city with pretty severe air pollution problems. If you could not change the air quality, how could you at least reduce the impact of the pollution on

your quality of life? Possibilities include the following:

a. install an air purification system in your home
b. live outside the city and commute in only to do your work
c. take a job in another city
d. use eyedrops to reduce eye irritation
e. wear a filtering mask

14. Ask: what costs are associated with each of these alternatives? Possible answers follow:

a. cost of buying, installing and operating the air purification system
b. commuting expenses: time lost, bus pass, auto expenses, parking
c. lower-paying job in another city
d. price of the eyedrops
e. the discomfort and possible social ridicule brought on by wearing the mask

Pollution Prevention Costs

15. Note that pollution costs may be prevented or reduced through waste management activities (treating wastes to reduce their harmful effects or practicing the "Four Rs": reduce, reuse, recycle, and refine — see Lesson Two) or by setting certain natural resource stocks or areas "off-limits" to development.

Use the following activities to demonstrate this point:

16. *The Costs of Waste Treatment*

Distribute Activity 3. This graph shows the cost of treating wastes resulting from petroleum refining before they are discharged into a waterway. Ask the students to answer the questions; discuss their answers.

a. 2 cents per pound
3 cents per pound
6 cents per pound
22 cents per pound
b. 2 + 3 = 5 cents per pound
2 + 3 + 3.5 + 4 = 12.5 cents per pound
2 + 3 + 3.5 + 4 + 6 + 7 = 25.5 cents per pound
2 + 3 + 3.5 + 4 + 6 + 7 + 14 + 16 = 55.5 cents per pound
c. For the very same reasons described above in procedural step 8. This may alternatively be explained by the fact that at first there are many control options available (e.g., adjust the nature of inputs or outputs, install control equipment, waste treatment, etc.). Clearly, the least expensive options are typically used first, leaving the more expensive cost options for further control.

17. *The Costs of Reduction*

Ask students list all the goods and services they have used in the past day. They should rank these items from "most willing and able to live without" to "least willing and able to live without." Next note that one of the simplest ways to reduce the loss of environmental quality is to produce (and consume) fewer products. This requires fewer natural resource inputs into the economy. Thus it not only reduces waste flows; it also leaves more natural resources in the environment to provide environmental quality. The cost of doing all this is the value of the products given up. At first this cost is small, since people can give up the items at the top of their lists. But as more reductions are made, people must move further down their lists,

and the cost (value forgone) rises: it is easier to give up a CD player than it is to give up food and shelter.

Another way to reduce the loss of environmental quality is to avoid excessive packaging of the products we use. Excessive packaging is often blamed for creating unnecessary wastes. Ask the class to discuss common packaging practices and the reasons why products might be packaged as they are.

Some packaging practices provide no value or even negative value to consumers — for example, packaging that is designed only to catch the consumer's eye or to make it appear there is more product inside than there actually is. However, some packaging does provide consumers with value — value which would be lost (that is, a cost) if the packaging were eliminated. For example:

a. keeps the product fresh
b. keeps the product sanitary
c. protects the product during shipping
d. allows for shelf display
e. provides consumer information such as directions or warnings
f. provides safety from tampering
g. reduces theft
h. makes the product cheaper and easier to transport

18. *The Costs of Reuse*

While reusing items (or avoiding disposable products) helps reduce waste (and potential pollution), reuse also involves costs. Have students consider the use of a ceramic cup versus a disposable paper cup. One valuable benefit of a disposable cup is the low risk of transferring disease. When a cup is used over again, precautions are usually taken. Ask the students to consider the precautions they would want to take in each of the following cases:

a. the cup is used only by you.
b. the cup is used only by members of your immediate family.
c. the cup is used by members of your family and their friends.
d. the cup is used by strangers.
e. the cup is used by strangers with highly contagious diseases.

Generally students will respond that more precautions would be desired as one moves down the list. In case (a), a simple rinsing of the cup in cold water may be all that one desires. In case (b), a wash in hot water may be necessary. In case (c), perhaps hot water and a detergent would be called for. In case (d) one might want boiling water, a detergent, and a sterilizing agent (you might mention state health requirements at restaurants here). In case (e), no amount of washing is likely to make reusing the cup desirable. Note that the costs (using resources which could be used to produce other valuable products: water, energy to heat the water, detergent, sterilizing agent, washer, etc.) of reuse can be significant, depending on how the cup is used.

Ask students to discuss the cost of using cloth versus disposable diapers. Points to discuss include the following:

As in the case of the cup, many of the health and safety benefits of disposable diapers would be forgone. In addition, the opportunity cost of the time to

rinse, wash, and dry cloth diapers is not paid by people who use disposable diapers.

19. *The Costs of Recycling*

Ask students to identify the opportunity costs associated with recycling activities. Points to discuss include the following:

Students should quickly recognize the resources required to collect, separate, transport, and reprocess recycled materials. These resources could be used to produce other valuable goods and services. The value of these forgone goods and services represent one cost of recycling. Students might also note that the time they spend sorting their recyclables represents another opportunity cost, since this time could be spent doing other satisfaction-providing (valuable) activities. See Lesson 18 for more activities concerning recycling and its costs.

20. *The Costs of Refining*

Distribute a copy of Activity 4 and provide 10 minutes for the class to answer the questions. Discuss their responses, using the following as a guide:

a. The slower hand-stamping for the "one-sheet" method means it will take longer to stamp out the cookies — that is, more of another resource (the hand-stampers) is required to produce the same amount of cookies. The additional hand-stampers required would be the cost of choosing this method.

b. If the price of hand-stampers is sufficiently high relative to the price of the dough, this change could end up costing more (the savings in dough is more than offset by the cost of extra hand-stampers).

c. Two possible suggestions: (1) Change the shape of the cookie (make rectangular cookies so no dough is wasted) and (2) change the composition of the dough so it can be reused. A potential cost of the first is that consumers may not like the new shape. The same can also be said for changing the composition of the dough. In the second case there is also the cost of collecting the "wasted" dough, repacking it, and spreading it out in a pan.

Many people call for increased "energy efficiency" (to reduce the flow of fossil fuels and their resulting wastes into the economy). But what might the costs be of improving the energy efficiency of our cars and homes? Ask students to answer this question, using the analysis of Activity 4 as their guide. Discuss as follows:

To improve energy efficiency requires more sophisticated engines which may take more time and resources to produce. Cars may also be made lighter or smaller, and such cars may cost the consumer a valuable product called "safety." To improve the energy efficiency of our homes would likely require increased construction costs for insulation or the opportunity cost of one's time spent making sure shades are drawn or left open when they should be to best capture "free" solar energy.

Closure: Global Warming

21. **Distribute a copy of Activity 5 to each student.**

22. Ask the students to identify several examples of each of the following:
    a. *Pollution costs*
    Pollution costs include any expenditures to avoid pollution losses once pollution has already occurred, plus any remaining losses. Avoidance costs include the lost production of valuable goods and services as resources are used to build dikes, air conditioners, and storage facilities. To the extent that these efforts are not successful, other costs will include the loss of agricultural products, water availability, and ecosystems, plus coastal flooding, unstable weather patterns, and the spread of disease.
    b. *Pollution prevention costs*
    Reduction costs (use less energy), refining costs (improve energy efficiency), recycling costs, storage costs, etc.
23. Note that while pollution prevention costs can lead to reductions in pollution costs, the question that still must be asked is "what is the right balance between these two costs?" (see Lesson Five).

EXTENSION ACTIVITIES

Science

24. Discuss the carbon cycle, especially noting the human-made sources of carbon dioxide, the absorption capabilities of forests and oceans, and the "greenhouse" effect associated with high concentrations of carbon dioxide in the troposphere.

Geography

25. Get topological maps of a coastal area. Ask students to trace a copy of the area; next, ask them to show with colors how the shoreline would change if the sea level were to rise by 20 ft., 50 ft., 100 ft., etc.
26. Discuss what would be lost in each case of change in the shoreline.

Community

27. Invite a speaker from a local landfill, sewage treatment facility, or waste-to-energy incinerator service to discuss the costs of siting, building, and operating the facility. You could also ask speakers from a local utility or industry to discuss the pollution abatement equipment they use and its costs.
28. Alternatively, divide students into research groups and assign them to acquire cost information through letters, on-site visits, or library research. Emphasize that while all cost information is in dollars and cents, these costs actually reflect the value of the resources used in alternative ways.

Economics

29. The economist's definition of pollution is more subtle and important than many students realize. To demonstrate, pose the following: "A lake contains 10 parts per million of substance X. Is the lake polluted?"
    According to an economist, the answer depends on whether or not this concentration of substance X reduces the value anyone receives from the environmental quality produced by the lake. Thus, there is no physical or historical standard that determines whether or not pollution has occurred.
30. Next pose the following: "Suppose another lake contains 20 parts per million of the same substance. Is

this lake more polluted than the first lake?"

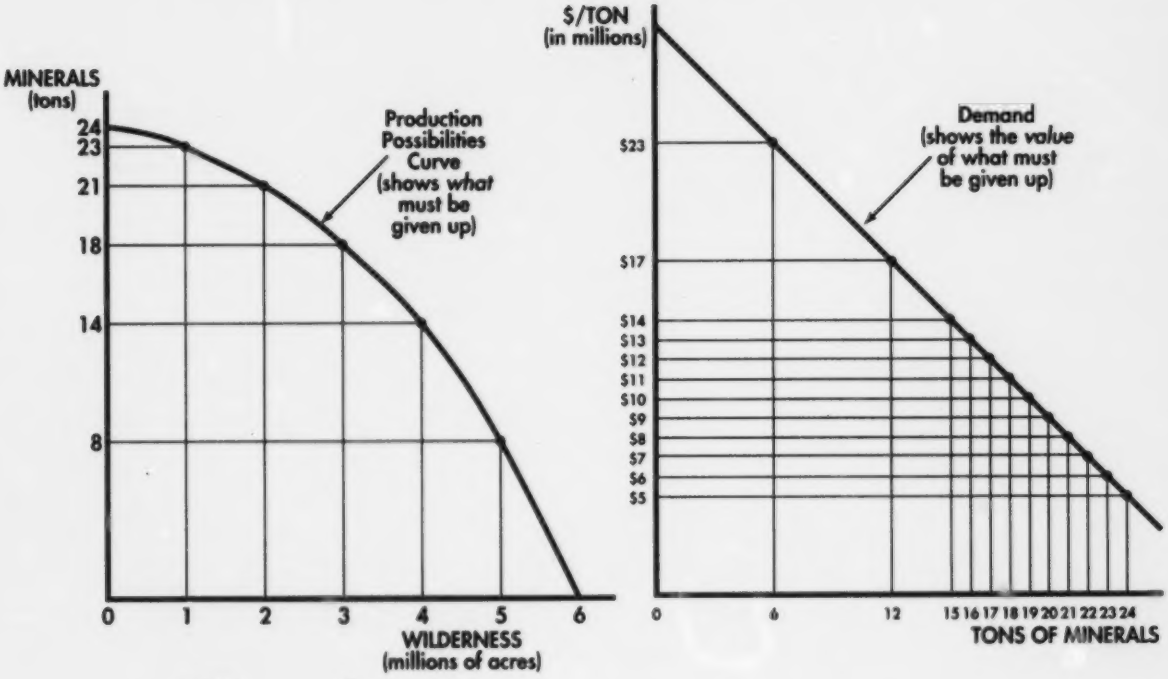
Most students and environmental scientists would say "yes," but from an economic perspective the answer could be "no," and in fact this second lake may even be less polluted than the first. Suppose the first lake is near a city. It serves the needs of a thriving ecosystem and is a prime location for swimming, boating, and fishing. Imagine that the second lake is in a more remote area with a fairly inactive ecosystem. In such a case, the value of the environmental quality lost as substance X is placed into the first lake may be far greater than that associated with dumping it into the second lake.

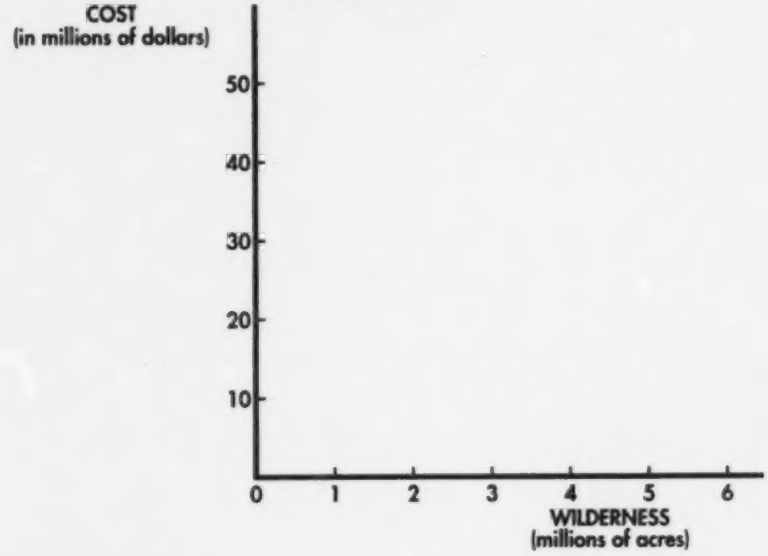
31. **Remind students that resources needed to control pollution are scarce. Ask: If there were enough resources to clean up only one of these lakes, which one would they clean?**

Answers will vary. Note that economists would likely spend these scarce resources on the first lake, while a biologist might argue that the second lake is in worse condition and should be cleaned first.

ACTIVITY 1

FINDING COSTS BY LOOKING AT THE VALUE OF WHAT IS GIVEN UP

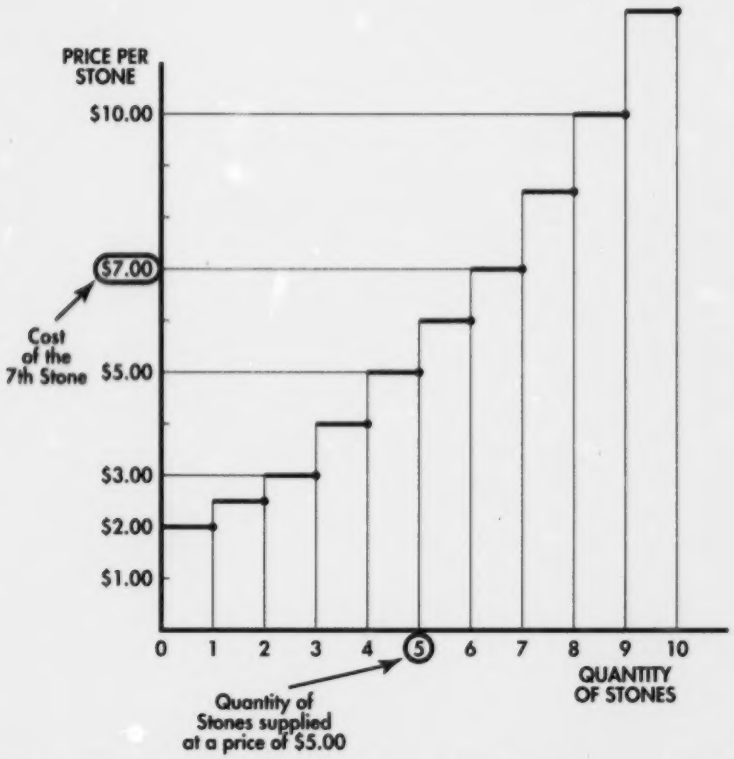




ACTIVITY 2

COSTS AND THE SUPPLY CURVE

Here is a cost curve like the one previously derived in class. It shows the cost (forgone value of the products the inputs used could have produced) of producing a special type of stone. The stone is valued for its reported ability to increase the intelligence of people who hold it. Given this, answer the questions below.



a. What is the cost of producing the 3rd stone? _____
... 6th stone? _____
... 9th stone? _____

b. What is the total cost of producing 2 stones? _____
... 5 stones? _____
... 7 stones? _____

c. How many stones would producers supply if the price they could receive was $10.00? _____
... $ 5.00? _____
... $ 2.00? _____

d. What general conclusion can you draw from (a)?

e. What general conclusion can you draw from (b)?

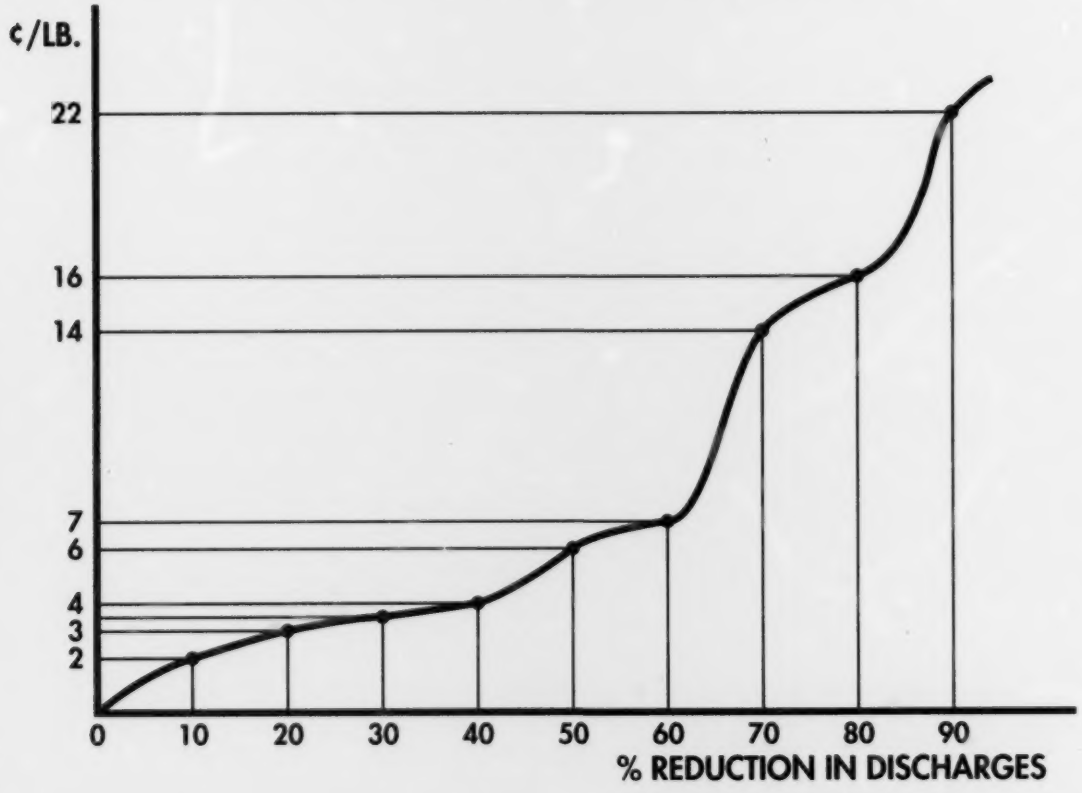
f. What general conclusion can you draw from (c)?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

THE COST OF CONTROLLING WASTES

The graph below shows the estimated cost of controlling each additional 10% of the waste discharges resulting from petroleum refining. The amount of discharged waste is measured in terms of reductions in BOD (biochemical oxygen demand). BOD is the number of pounds of oxygen required to decompose the organic material contained in the waste discharge. Based on this curve, answer the questions below.



a. What is the cost of reducing the first 10%? _____
... second 10%? _____
... fifth 10%? _____
... ninth 10%? _____

b. What is the total cost of reducing waste discharges by 20%? _____
... 40%? _____
... 60%? _____
... 80%? _____

c. Why would you expect this curve to be upward-sloping as shown?

ACTIVITY 4

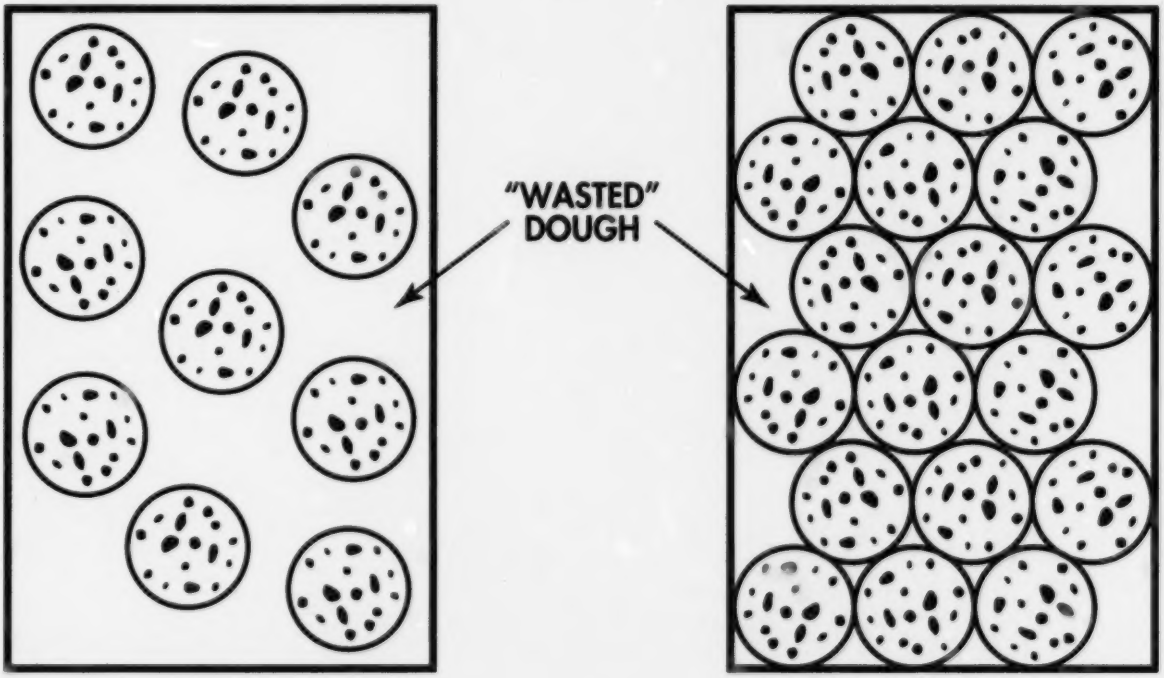
MORE COOKIES, LESS WASTE

Read the following:

An old-fashioned cookie company has been producing cookies in the same way for years. Dough is rolled out in pans and bakers' helpers quickly hand-stamp out about nine cookies per pan, as shown in diagram (1) below. Because of the special nature of the dough used, the wasted dough can not be recombined and respread—it can only be thrown away. A new trainee seeing all this waste suggests a refinement of the production process. She suggests being more careful in the hand-stamping step so that cookies can be stamped out in the pattern shown in diagram (2). She notes that this change in the production process not only doubles the number of cookies per sheet but also reduces waste. "Plus," she adds, "it costs nothing!"

Answer these questions:

a. Give a reason why the trainee's last statement is probably not true.
b. Could the trainee's suggestion actually cost the company more than the handstamping method it uses now? Explain your answer.
c. Suggest some other ways to reduce the amount of dough wasted. Also note any costs associated with these methods.



(1) (2)

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 5

GLOBAL WARMING

The average temperature of Earth's surface is affected by the amount of heat trapped in the troposphere by "greenhouse gases." The principal greenhouse gases introduced into the atmosphere by humans are carbon dioxide, chlorofluorocarbons (CFCs), methane, and nitrous oxide. The average concentration of these gases (measured in parts per billion) has increased over time due to the burning of fossil fuels, the use of CFCs (in air conditioners, refrigerators, and as a propellant in aerosol spray cans), the expansion of agriculture (methane gas from livestock and water-logged soils), and deforestation. Although scientists disagree on the magnitude and speed of the effect, if current trends continue it is estimated that by the year 2050 the average temperature of the Earth's surface could be from 1.5 - 5.5 degrees Centigrade warmer than it is now.

The damages associated with this warming trend are difficult to know with certainty. If likely shifts in agricultural regions occurs, whole new areas with questionable soils and water availability would need to be developed. Crop and food production could fall substantially. In some areas water might become scarce, destroying entire ecosystems and forcing population migrations to other areas. Tropical diseases would likely spread to the temperate zones. Weather patterns could become more unstable (longer droughts and more severe storms). Finally, a rising sea level (due to water expansion alone or complemented by a partial or complete melting of polar ice sheets) would inundate many coastal ecosystems and effectively destroy many cities (including New York, Shanghai, Cairo, Venice, Miami, New Orleans, and Bangkok) and wipe out whole islands.

Some of these damages might be mitigated or avoided through the increased use of air conditioning, the building of dikes to protect coastal areas from flooding, protecting ecosystems in new areas, and storing food and water in case of disruptions in their supply.

To prevent or slow down global warming requires that we reduce our emissions of greenhouse gases. Carbon dioxide emissions could be reduced by cutting our use of fossil fuels (particularly coal), increasing energy efficiency, halting deforestation, and developing ways to recycle emissions or capture and store them in deep wells. The use of CFCs has already been reduced, but alternative refrigerants need to be developed. Methane emissions could be reduced by means of improved agricultural practices and by recycling methane emissions from landfills. If we changed our diets, so that our food supply depended less on livestock, that also would help reduce methane emissions.

No matter how we respond, our response will involve costs of some kind.

HOW CLEAN IS CLEAN ENOUGH?

INTRODUCTION

What is the "right" amount of environmental quality — or, conversely, what is the "right" amount of pollution? What is the "right" amount of rainforest acres or whales? Every day markets determine the amount of various products to be produced. Whether this amount is the "right" amount or not depends upon what criterion or goal one chooses to use. In this lesson students learn how to decide upon the "right" amount by reference to the goal of maximizing the value society receives from its resources — a goal economists call "allocative efficiency."

ECONOMIC CONCEPTS

Social Goals
Allocation of Resources
Allocative Efficiency
Cost Effectiveness
Net Value

ENVIRONMENTAL CONCEPTS

Ambient Standard

OBJECTIVES

- Identify alternative social goals in evaluating resource use.
- Define allocative efficiency.
- Explain how the "right" amount of a product to produce is found, assuming the social goal of allocative efficiency.
- Apply the allocative efficiency criterion to the product, environmental quality.

LESSON DESCRIPTION

The following activities begin by looking at various social goals before focusing on the goal of allocative efficiency. This criterion forms the basis of the economic way of thinking — a weighing of the benefits and costs. The culminating application considers the setting of air quality standards and the extent to which this criterion was used.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-8
Day 2: Steps 9-12 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 3, and 4
A transparency of Activity 2 and 5

PROCEDURE

Social Goals

1. Ask the students to suggest what the broad social goals are that we might consider as we decide how natural resources should be used. List the goals on the board.
   Responses might include the following:
   a. economic growth — maximize the growth in real GDP (gross domestic product — the market value of all final goods and services produced in a country)
   b. job creation (full-employment) — maximize the number of jobs
   c. equity (fairness) — use resources in the "fairest" way
   d. environmental protection — minimize the impact on the environment
   e. income generation — maximize the amount of income generated
   f. cost-effectiveness — produce products in the least-costly way possible
   g. sustainability — meet the needs of the present generation

without compromising the ability of future generations to meet their own needs

h. allocative efficiency — maximize the total value generated from resource use (be sure to suggest this one if students don't come up with it on their own)

i. energy efficiency — minimize the amount of energy required to produce or use a product

Efficiency: What Does It Mean?

2. Present the following problem to the students: Suppose there are two kinds of drill bits that may be used to drill for oil — one made of a special steel alloy, the other of diamonds. The hardness of diamonds allows the diamond drill to cut through 10,000 feet of rock before it must be replaced. The steel bit must be replaced every 2000 feet. The diamond bit costs $2000 while the steel bit sells for $300. Which drill bit is more efficient?

   The diamond bit is more efficient in that it can perform five times the work of the steel bit, but the steel bit is more efficient in that it can cut through 10,000 feet of rock at a lower cost (5 X $300 = $1500 versus $2000).

3. Note that efficiency is defined according to "getting the most" of something (the diamond bit yields the most work while the steel bit yields the most work per dollar), or alternatively as achieving some objective with "the least amount" of something (the fewer bits are used to drill 10,000 feet if diamond bits are used while the least cost is incurred if steel bits are used).

4. Assign the students to complete Activity 1. Allow 10 minutes; then discuss their answers:

   a. 1; 4; 3

   b. (10 x $1) + (90 x $5) + (40 x $2) = $540;
   (20 x $1) + (70 x $5) + (35 x $2) = $440;
   (100 x $1) + (40 x $5) + (30 x $2) = $360;
   (200 x $1) + (30 x $5) + (35 x $2) = $420

   c. 3 (produces 200 units for the least cost)

5. Note the difference between the efficiencies discussed in Activity 1 and "allocative efficiency." Allocative efficiency occurs when resources are allocated to the uses that generate the most value to society. Use cars as an example to show the different meanings of efficiency:

   energy efficiency: getting the most miles per gallon of gas (or going a fixed number of miles using the least amount of gas)

   cost efficiency (cost effectiveness): producing the greatest number of cars for a given amount of money (or producing a car for the least amount of money)

   allocative efficiency: getting the most value from resources (that is, producing cars as long as there is no other use for the resources that could generate greater value).

Allocative Efficiency and the Production Possibilities Curve

6. Show a transparency of Activity 2. Discuss the trade-offs illustrated by this curve (see Lesson 1, Activity 3). Note that as society changes the way it chooses to allocate and use its resources — from A to B to C and on through F — the level of environmental quality improves and the amount of other goods and services falls.

7. **Ask the class: How far down the curve should society choose to go if its goal is allocative efficiency? Discuss responses.**

   As long as the value of the gain in environmental quality improvement exceeds the value of the products given up, allocative efficiency says to keep going. However, society will likely reach a point (say, moving from D to E) where this is no longer true. Then point D would be the allocatively efficient choice — depicting the "right" amount of environmental quality and the "right" amount of other products.

The "Right" Amount of Wilderness

8. **Distribute Activity 3 and have students complete it individually; discuss responses:**

   a. 1st: $44 - $5 = $39
   2nd: $36 - $13 = $23
   3rd: $28 - $27 = $1
   4th: $20 - $50 = -$30
   5th: $12 - $105 = -$93

   b. Yes, the second million acres of land generates $36 million in wilderness value and would generate only $13 million if used for minerals production.
   No, the fifth million acres of land generates only $12 million in wilderness value, but would generate $105 million if used for minerals production.

   c. 3 million acres for each: up through the third million acres the value of the land as a wilderness preserve exceeds the value of the minerals that could be extracted from it.

   d. Plot the points (1,44), (2,36), (3,28), (4,20), and (5,12) to form the "value" curve (the first number denotes the amount of land used for wilderness preservation from Column 1; the second denotes the "value received" from Column 2). Next plot the points (1,5), (2,13), (3,27), (4,50), and (5,105) to form the "cost" curve (the first number denotes the amount of land used for wilderness preservation from Column 1; the second denotes the "cost incurred" from Column 3). Note that the value curve is downward-sloping, as described in Lesson 3, and the cost curve is upward-sloping, as described in Lesson 4.

   e. It occurs at that amount where the two curves intersect. At amounts less than this, note that the value of each additional million acres (indicated by the height of the value curve) exceeds the value forgone by using the land for mineral production (indicated by the height of the cost curve). At amounts greater than this, the opposite is true.

The "Right" Amount of Ooze

9. **Ask: What is the "right" amount of a pollutant to produce?**

   Many students will likely say "zero."

10. **Note that from the perspective of allocative efficiency, the answer might not be zero, because the cost of controlling and treating a pollutant may exceed the value of the improvement in environmental quality. To demonstrate this, distribute Lesson 5, Activity 4, and assign students to complete it, working in groups or individually. Allow at least 10 minutes. Discuss their responses, as follows:**

Tons of Ooze	Value Added	Cost Added	Total Value	Total Cost	Net Value
1	$10	$1	$10	$1	$9
2	9	2	19	3	16
3	8	4	27	7	20
4	7	6	34	13	21
5	6	9	40	22	18
6	5	12	45	34	11

a. The "Value Added" and "Cost Added" columns are read from the respective curves. "Total Value" sums the value added by each ton (for example, the total value of controlling three tons is the value added by the first [$10], the second [$9], and the third [$8], or $27 [=10 + 9 + 8]). "Total Cost" similarly sums the costs added by each ton. "Net Value" is simply "Total Value" minus "Total Cost."

b. Four tons controlled: net value equals $21.

c. Also four tons controlled. Note that controlling further requires resources which are more highly valued somewhere else (as indicated by the "Additional Cost" curve) than they are in producing more control (as indicated by the "Additional Value" curve).

Setting Air Quality Standards

11. Show a transparency of Activity 5. Relate the following to the students: These are the original concentration levels of several air pollutants set by the Environmental Protection Agency. In one sense, anything less than these standards is acceptable, but anything greater is not. The Clean Air Act of 1970, which required the establishment of these standards, prohibited the use of a balancing of benefits and costs in their determination. The primary standard instead was based on the concept of a "health threshold." The standard is to be defined "with a margin of safety sufficiently high that no adverse health effects would be suffered by any member of the population as long as the air quality was at least as good as the standard."

12. Lead class discussion by asking the following:

a. Using the rule stated above, if some small segment of the population was susceptible to adverse health effects from even the lowest levels of some pollutant, where should the standard be set?

Near zero

b. What is the likelihood that someone somewhere in the population is that susceptible?

Probably very high.

c. What does that suggest about these standards?

Other criteria were probably unofficially used.

d. Does it seem reasonable to exclude the costs (what society must give up in terms of other valuable products) in determining how much of the good (air quality) we should have?

From the perspective of allocative efficiency, no.

e. The 1972 amendments to the Water Pollution Control Act stated in a preamble "that the discharge of pollutants into navigable waters be eliminated by 1985." In other words, the "right" level of discharge is zero. Is this likely to be the allocatively efficient level?

Control costs would likely be too high.

f. Under what circumstances might zero be the right level?

Insignificant or low control costs and/or prohibitively high damages given even the slightest discharge.

EXTENSION ACTIVITIES

Math

13. Explain that in determining whether or not its standards are being met, the EPA takes air samples at various times and then determines what the "average" concentration level is at a given site. There are many ways to find the "average" of a sample of n numbers. The most common is the "arithmetic mean," which is obtained by dividing the sum of the n numbers by n. Another is the "geometric mean," which is the nth root of the product of the n numbers. For example, given the numbers 2, 4, and 8: the arithmetic mean = (2 + 4 + 8)/3 = 4.67; the geometric mean = the cube (or third root) of (2 x 4 x 8 = 64) = 4.
14. Ask students to compute both means for the following sets of numbers (answers follow in parentheses):
    a. 10, 10, 10 (both means = 10)
    b. 4, 6, 8, 10 (a.m. = 7; g.m. = 6.62)
    c. 10, 10, 10, 50 (a.m. = 20; g.m. =14.95)
    d. 7, 10, 13 (a.m. = 10, g.m. = 9.69)
15. Ask: How do the values of these two means compare? Answers follow.

    The geometric mean is smaller, unless all the numbers are the same (in which case both means are equal).
16. Some air quality standards are based on an arithmetic mean of several observations, while others are based on a geometric mean. Which mean makes the standard easier to meet?

    Geometric, based on the answer above.

Family Studies

17. Ask students to think about how clean they keep their bedrooms at home. What are the benefits and costs? The benefits gained from cleaning include avoiding criticisms from parents, being able to find things more quickly, decreasing one's health risk from mold and dust mites, etc. The costs include the time, cleaning supplies, and equipment required to do the cleaning.
18. Ask if anyone has an absolutely spotless room (every speck of dust eliminated, no wrinkles in the bedspread, no items out of place, etc.).

    Probably no one does — the costs of being that clean are just too high. Relate this point to environmental quality in general: just how clean are we really willing to keep the world?

Community

19. Investigate environmental standards (air and water quality) in your area. If possible, invite those responsible for establishing these standards to visit your class and discuss the basis for their choice. Your best contacts would likely be your state pollution control agency.

Government

20. Assign students to research the latest air quality standards established by the Environmental Protection Agency (that is, update all entries in Activity 5). They also should seek to learn the rationale behind any changes that have been made. The best source of information for this task would be the *Code of Federal Regulation*, Volume 40.

ACTIVITY 1

EFFICIENCY: WHAT DOES IT MEAN?

A company can produce 200 camping kits per day in four different ways. The daily input requirements of four of these methods are shown below. Suppose the price of a kilowatt of electricity is $1, the machine rate per hour is $5, and the cost of raw materials used is $2 per pound.

	Production Alternatives			
Input Requirements	1	2	3	4
Energy (kwh of electricity)	10	20	100	200
Capital (machine hours)	90	70	40	30
Raw Materials (pounds)	40	35	30	35

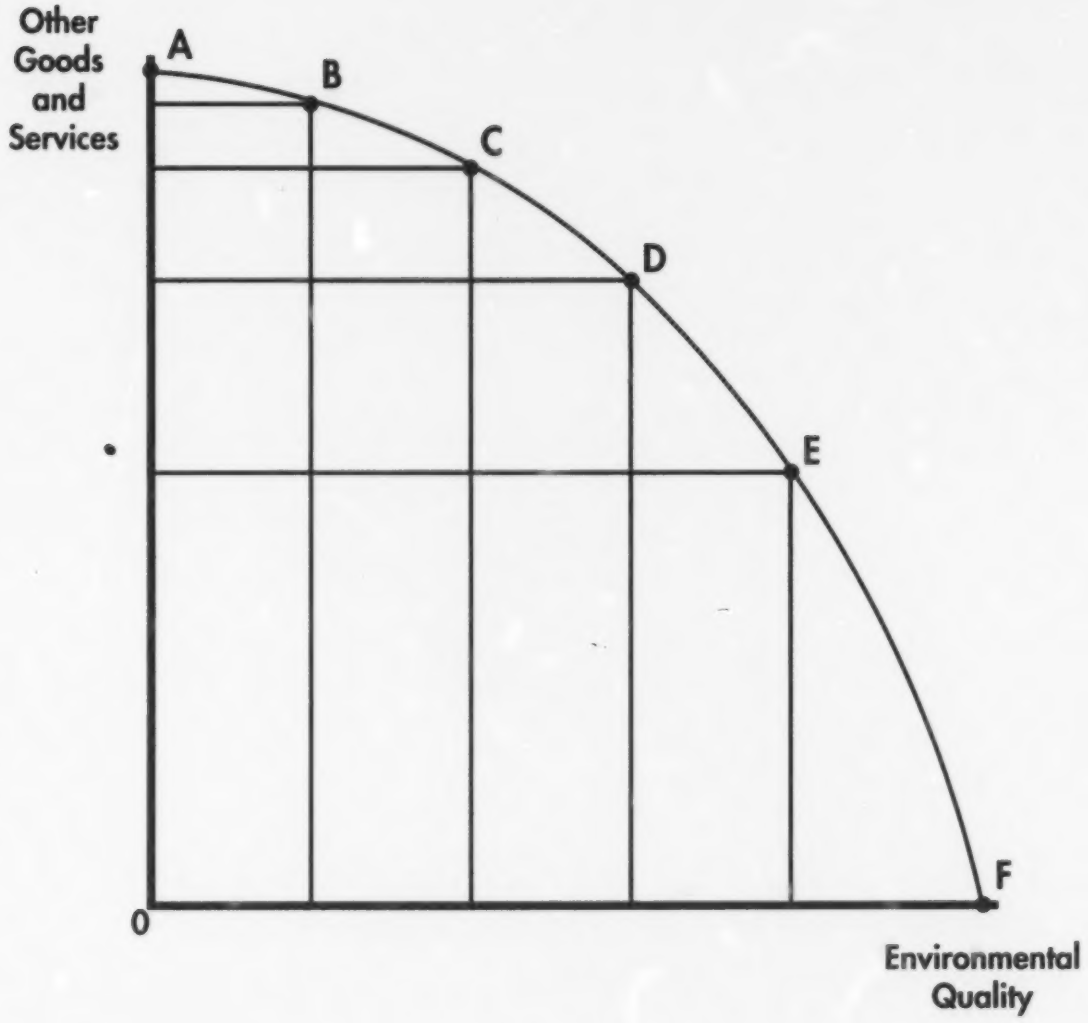
a. Which alternative is the most energy-efficient (that is, uses the least amount of energy to produce 200 kits)? _____
. . . capital-efficient? _____
. . . material-efficient? _____

b. What is the total cost of alternative 1? _____
. . . of alternative 2? _____
. . . of alternative 3? _____
. . . of alternative 4? _____

c. Given your answers in (b), which alternative produces the 200 kits for the least cost (that is, which is the most cost efficient or cost-effective alternative)? _____

ACTIVITY 2

ALLOCATIVE EFFICIENCY AND THE PRODUCTION POSSIBILITIES CURVE



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

THE "RIGHT" AMOUNT OF WILDERNESS

Ecoland has six million acres of land that can be used as a wilderness preserve or mined for minerals to produce various consumer products. Column 2 below shows the value (in millions of dollars) the people of Ecoland receive from each additional million acres devoted to wilderness preservation. Column 3 shows the value to them of the minerals that would have to be given up if the land is used for wilderness products. This value represents the lost opportunity or cost of additional wilderness preservation.

COLUMN 1	COLUMN 2	COLUMN 3
Wilderness Preserved	Value Received	Cost Incurred
1st million acres	$44	$5
2nd	36	13
3rd	28	27
4th	20	50
5th	12	105

Directions:

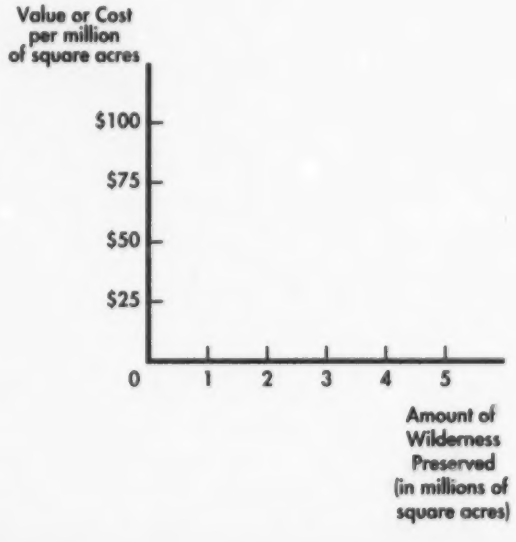
a. Calculate the net value (the value received minus the value forgone — the cost incurred) of each additional million acres of wilderness preservation.

b. If Ecoland's goal is to maximize the value received from its land, should the second million square acres of land be devoted to wilderness preservation? How about the fifth?

c. If Ecoland's goal is to maximize the value received from its land, how much land should be devoted to wilderness preservation and how much to minerals production? Why?

d. Graph the "value received" curve (using Columns 1 and 2) and the "cost incurred" curve (using Columns 1 and 3) below.

e. How can the allocatively efficient amount of wilderness preservation be found by looking at these curves?

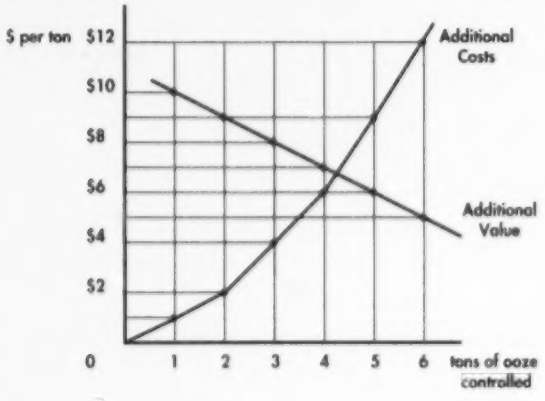


ACTIVITY 4

THE "RIGHT" AMOUNT OF OOZE

Read the following and answer the questions below:

"Ooze" is a pollutant that causes pollution damages (reduces people's environmental quality). As ooze is controlled, these damages are reduced and people enjoy increased environmental quality. The value of this increase is shown by the "Additional Value" curve below. Controlling ooze, however, requires that resources be diverted from other valued uses. The "Additional Costs" curve below shows the value lost as more resources are used in controlling ooze.



a. Use the graph above to complete the following table:

Tons of Ooze Controlled	Value Added	Cost Added	Total Value	Total Cost	Net Value
1					
2					
3					
4					
5					
6					

b. At which level of control is net value the greatest?

c. Which level of control is the "right" level, given the criterion of allocative efficiency? Why?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 5

ORIGINAL NATIONAL AMBIENT AIR QUALITY STANDARDS

		Primary Standard	
Pollutant	Period of Measurement	Micrograms/ cubic meter	Parts/ million
Carbon Monoxide	8 hours	10,000	9.00
Carbon Monoxide	1 hour	40,000	35.00
Hydrocarbons	3 hours	160	0.24
Nitrogen Dioxide	1 year	100	0.05
Ozone	1 hour	235	0.12
Sulfur Oxides	1 year	80	0.03
Sulfur Oxides	24 hours	365	0.14
TSP (Total Suspended Particulates)	1 year	75	NA
TSP	24 hours	260	NA
Lead	3 months	1.5	NA
			140

Notes: Concentration levels are averages over the period of measurement. The annual TSP concentration is a geometric average of 24-hour samples; all others are arithmetic averages.

Source: *Code of Federal Regulations*, Vol. 40 (1982).

UNIT 3

THE ECONOMIC ROOTS OF ENVIRONMENTAL PROBLEMS

IT'S FINE AS LONG AS IT'S MINE — ALL MINE!

INTRODUCTION

Capitalism is based on the concept of private property — the ownership and control of resources and products by individuals. If property rights are well-defined and markets are competitive, such a system ensures that resources are used in their most valued manner. That is the beauty of capitalism. But the "if" is a big one. What happens when property rights are not well defined?
Unfortunately, property rights to many natural resources are poorly defined. In this lesson students learn about property rights and how property rights can affect the way markets allocate resources.

ECONOMIC CONCEPTS

Private Property
Property Rights
Well-defined Property Rights
Self-interest Motives
Economic Incentives
Market
Price
Equilibrium
Allocative Efficiency
Common Property Resource

ENVIRONMENTAL CONCEPTS

Water Rights

OBJECTIVES

- Review how the price and quantity produced of a product are determined by markets.
- Define and give examples of property rights.
- Describe the characteristics of well-defined property rights.
- Analyze the effect of property rights on the allocation of resources.
- Explain the government's role in establishing and protecting property rights.

LESSON DESCRIPTION

In determining the price and the quantity of notebooks produced in a hypothetical market, students review how markets work. Property rights are defined. The Guide to Ideal Markets is presented and used to identify situations in the notebook market and natural resource markets where markets may lead to results that are not allocatively efficient. A game is used to illustrate how property rights affect economic incentives and resource allocation. Parallels between the game and the plight of whales are drawn. The culminating activity focuses on how property rights to water have been defined. Some economic consequences of this approach to establishing property rights to water are explored.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-11
Day 2: Steps 12-29 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 2, 3, 4, 5, and 6
50 paper clips
50 dimes
A roll of masking tape
Space! (an area of the floor at least six feet by six feet needs to be cleared)

PROCEDURE

Markets, Prices, Quantity, and Allocative Efficiency

1. Review market basics (as necessary): (1) a market is where buyers and sellers get together to exchange products or resources; (2) demand shows how much buyers are willing and able to buy at various prices; (3) supply shows how much sellers are willing and able to produce and sell at various prices; (4) the price established by the market is that where the quantity demanded by buyers equals the quantity supplied by sellers.
2. Distribute a copy of Activity 1 and its accompanying worksheet to each student and discuss what the activity shows.
3. Assign students to complete the worksheet (allow 20-30 minutes).
4. Discuss the answers in class, as follows:
   a. 10; 30; 40
   b. In deciding whether or not to buy a notebook, students compare the value they expect to receive from the notebook to its price. It is in their self-interest to buy notebooks whenever the value they receive exceeds the price. As the price rises, fewer students value a notebook enough to buy one.
   c. 40; 20; 10
   d. In deciding whether or not to produce notebooks, producers compare their own costs (for the resources needed for production) to the price they can charge for the finished product. It is in their self-interest to produce all notebooks for which the price exceeds the cost. As the price rises producers are able to cover the cost of producing additional notebooks.
   e. $10. If the price is above $10, the quantity produced and offered for sale by sellers will exceed the quantity desired by consumers. A surplus then is said to exist. The surplus places downward pressure on the price as sellers reduce their prices to clear unsold notebooks. If the price is below $10, the quantity produced and offered for sale by producers is less than the quantity desired by buyers. In this case a shortage exists. The shortage puts pressure on the price to rise as buyers bid against each other in an attempt to get a notebook before they run out. Thus, the price tends to move towards $10 — where the desires of the students and the notebook producers are consistent with one another.
   f. 30 notebooks
   g. $20; $15; $10; $7 (see Lesson 3)
   h. $5; $7; $10; $15 (see Lesson 4)
   i. 30. For each notebook up through the 30th, the value received (shown by the demand curve) exceeds the cost (forgone value of using the resources in their next best alternative — shown by the supply curve). After the 30th notebook the opposite is true (see Lesson 5).
5. Note that maximizing the net value society receives from a product means that society is achieving allocative efficiency. Thus, this exercise demonstrates two points: (1) that markets set prices, (2) that markets determine the allocatively efficient amount of a product to produce. But

markets can achieve these results only if demand curves accurately represent society's values and supply curves accurately represent its costs.

Property Rights

6. Relate the following to the class: Capitalism is based on private property, or the ownership and control of resources and products by individuals (as opposed to the government). In actual practice, private ownership of property depends on a system of "property rights" — legal or social arrangements that govern the ownership, use, and exchange of goods and resources. These arrangements typically involve limitations as well as privileges.
7. Break the class into five groups and ask each group to describe the typical property rights (privileges and limitations) associated with one of the goods listed below. Someone from each group will report to the class for discussion. Possible answers follow.

apple
privileges: can eat it, carve it, or make it into applesauce;
limitations: can not throw it through the school window or smash it in someone's face

motor oil
privileges: use in your car, lubricate your tools;
limitations: can not dispose of it on the ground or down the sewer or burn it in your backyard

rented apartment
privileges: can arrange the furniture, sleep in the kitchen, or entertain guests;
limitations: depending on the terms of your lease, no pets, no remodeling

rifle
privileges: use on target range, use to hunt, have in a collection
limitations: can not fire at 2 a.m. in your home, shoot a bald eagle, or sell to a known felon

air
privileges: can breathe, emit auto exhaust in to, or use to grow plants;
limitations: can not fly or smoke in certain areas

Well-defined Property Rights and Competitive Markets

8. Distribute a copy of Activity 2 (The Guide to Ideal Markets) to each student. Discuss how each of these characteristics is met by the notebook market described in Activity 1. Note that if all these characteristics exist in a market, the market demand curve accurately reflects the value society assigns to a product and the market supply curve accurately reflects the cost society must bear to produce the product. Thus, market equilibrium leads to the allocatively efficient quantity of the product.

Problems in the Notebook Market

9. Distribute a copy of Activity 3 to each student. Ask students working in groups of three to four to complete the activity.
10. Allow 10-15 minutes and then discuss the responses, as follows:
    Each of these conditions in the notebook market violates one of the characteristics of "well-defined" property rights listed in The Guide to Ideal Markets. When any of these characteristics is violated, it is likely that the supply curve no

longer reflects the costs to society or that the demand curve no longer reflects the value to society. In either case, the equilibrium quantity determined by the market is no longer likely to be the quantity which maximizes the net value society gets from the product (that is, it is not allocatively efficient).

a. Ownership of the notebooks is not clearly defined as between the producers and the students. In this case there is little incentive for the producers to produce notebooks since students are given the right to use them without paying. No incentive to supply means the market production will be zero. Since the value to students and the cost to producers remains as shown in Activity 1, however, this amount (zero) is less than the "right" amount of 30. This is a violation of the "universality" condition.

b. The production of notebooks is imposing a cost on society that the producers are probably not taking into account in their supply decisions. Since the actual cost to society is greater than that to which producers are reacting, supply understates actual costs and so the market produces more notebooks than it should. This is a violation of the "exclusivity" condition.

c. Since college students are not allowed to buy notebooks, the value of notebooks to them would not be reflected in the market. Thus, market demand would understate the true value of the notebooks and so the market would produce fewer notebooks than it should. This is a violation of the "transferability" condition.

d. The consumption of notebooks generates value for others that students probably do not consider in their demand decisions. Since the actual value to society is greater than that envisioned by the students, demand understates the actual value and so the market produces fewer notebooks than it should. This is a violation of the "exclusivity" condition.

e. Even though students would still value being able to use these notebooks, their demand for them would likely be zero. There is no incentive to buy a notebook because it might be taken away. No demand means no market production. This is a violation of the "enforceability" condition.

11. **Ask the class to suggest environmental examples that would violate each of the characteristics shown on The Guide to Ideal Markets. Possible examples follows:**

Universality: air in the classroom, whales in the ocean, the moon, migratory birds, the ozone layer, etc., are not privately-owned (i.e., they are not controlled by an individual or a private business).

Exclusivity: costs of pollution-creating activities are seldom confined solely to the polluter; the benefits of a beautiful garden can be enjoyed by people other than the owner.

Transferability: hunting licenses and water rights are often not transferable.

Enforceability: even though the government may attempt to define rights (such as declaring ownership rights 200 miles out to sea, setting hunting limits,

banning the use of certain chemicals, prohibiting dumping), it is difficult to enforce these rules given the vast size of the area which must be patrolled.

Lack of Economic Power: many natural resource industries are dominated by a few large firms which can influence supply and therefore influence price.

Free Mobility: ownership or leasing of major ore deposits by firms already in many mineral industries creates a barrier to firms wishing to enter these industries.

Perfect Information: the effect of many pollutants on climate, people's health, plants and animals, and ecosystems in general is still very much unknown. People's demand for some products might change if this information became available.

Property Rights and Incentives

12. Explain that this activity provides another example of how incentives are affected by property rights (in this case, the "universality" condition of The Guide to Ideal Markets has not been met).
13. Ask for 10 volunteers for a lucrative job (flash a $5 roll of dimes!). The volunteers should go to a cleared area of the room and form a circle. The circle should have a diameter of at least six feet (bigger if possible).
14. Take 50 paper clips and toss them on the floor inside the circle. Tell the students that they are going to be paid to pick up the clips. Tell them there will be two periods in which they may pick up the clips. In the first period they will be paid a dime for each clip they pick up, while in the second period they will be paid twenty cents for each clip they pick up. Note that only those clips not picked up in period one will be available to be picked up in period two. Finally, note that each period will last for only one minute and that clips must be turned in in the period in which they were picked up.
15. Ask if everyone understands; then begin period one. Although there may be some talk (colluding!) about waiting, soon someone will start gathering up the clips as fast as he or she can, and everyone else will jump in. All the clips will be picked up in period one! Pay the students!
16. Next use masking tape to line the floor in a tic-tac-toe pattern. Have one student stand in each cell and have the tenth student stand off to the side. Again toss the clips on the floor so that they fall into the various cells. Tell the students you are going to repeat the game, again paying a dime for every clip picked up in the first period and twenty cents for clips picked up in the second. However, this time students may only pick up clips in their own cell.
17. Begin period one. Not too surprisingly, none of the clips is now picked up. Thank students for participating and tell them that the second period will begin as soon as you win the lotto! Ask the students to return to their seats.
18. Ask: If the goal of society is to get the most value from its scarce resources (i.e., allocative efficiency), when should the clips have been picked up?

    In the second period, since the willingness and ability to pay for them (their value) then is greater — twice as much.

19. **Note that this happened the second time the game was played but not the first. Ask: What was different?**
    Property rights to the clips were assigned the second time.
20. **Ask: How did the assigning of property rights change the incentives of the players? Discuss responses.**
    Because players could control when their clips would be picked up during the second round, they received the benefit of waiting. In the first round, their waiting might have cost them the opportunity to get anything at all.
21. **Relate this game to the harvesting of whales (the floor is the "ocean," the clips are the "whales," and the students are the "whale hunters"). Note that no one has the incentive to manage or control the stock of whales, since they don't own them and can't control others' access to them. Thus, the exploitation of whales can be traced to a lack of adequately defined property rights.**
22. **Next ask students to think about the amount of beef and chicken consumed every day in the United States. Ask: Why aren't we worried about "Saving the Cattle" or "Saving the Chickens" as some are concerned about "Saving the Whales"? Possible answer follows:**
    Cattle and chicken stocks are privately owned. Thus, if a rancher foresaw pending extinction or a future shortage of cattle, she would withhold her cattle from the market today to take advantage of the higher expected price in the future. Thus, private property rights provide the incentives for owners to sell their resources at the time when the resources are most highly valued.
23. **Ask: What other resources are like whales? (You might help students get started by asking who owns the air in the room.)**
    Possible answers include:
    air, groundwater, oil pools, wildlife species — eagles, deer, coyotes, ducks, tuna, etc.
24. **What does the game played today suggest about how these resources would be used in the absence of any outside intervention?**
    They might be overused and/or used too quickly from the perspective of allocative efficiency.

An Economic Function of the Government

25. **Explain that a major economic function of the government is to define and enforce property rights.**
26. **Ask students to discuss how the government has defined property rights or "rules of the game" for environmental resources.**
    Some suggestions follow:
    Air and water: The Environmental Protection Agency sets national ambient standards, while states establish allowable emissions of various substances to meet these standards.
    Wildlife: the Department of the Interior and state Departments of Natural Resources establish hunting and fishing seasons and quotas to control the harvest of wildlife species.
    Scenic forests and wilderness areas: the National Park Service and various state agencies establish camping and other rules of use for these areas.
    Ocean fisheries: 200-mile limit, harvest quotas.

Water Rights

27. **Explain that this final activity highlights the importance of being able to transfer property rights in order to get the most value from a resource — in this case water.**
28. **Distribute a copy of Activity 4 and its accompanying worksheet to each student. Ask students to read Water Rights and complete the worksheet.**
29. **Allow 30 minutes; then discuss their responses, as follows:**
    a. Total benefit of two units is $39, while for one it is $20; thus the second unit added $19. Similarly, the fifth unit adds $16, the eighth adds $13, and the tenth adds $11.
    b. Suppose that User A is a typical residential consumer. The first units of water are very valuable for basic survival (drinking and cooking). The next units might be used to satisfy less pressing health needs such as bathing, flushing a toilet, and washing clothes. Later units would satisfy such wants as washing the car or watering the lawn. The final units of water might be used to run an ornamental fountain. The point is that the benefits received from additional units of water (or any good in general) tend to decrease as the more important wants and needs are satisfied. One could also discuss agricultural uses of water in terms of the diminishing productivity of water.
    c. i. 8 units for User A: $132
    ii. 8 units for User A: $162
    iii. 6 units for User A, 2 units for User B: $105 + $57 = $162
    iv. 2 units for User A, 6 units for User B: $39 + $136 = $175
    v. Note that the value of benefits received by User A for the 8th unit is $13, while User B would receive $30 in benefits from it. Thus, User A would be willing and able to sell it for any amount over $13, while User B would be willing and able to buy it for any amount less than $30. This gives plenty of room for the two to negotiate a transfer. The same is true for User A's 7th, 6th, 5th, and 4th units. Through trades, User A ends up with 3 units and User B with 5: $57 + $120 = $177.
    vi. Trading yields the same result as in v. Emphasize that being allowed to transfer the water through trades yields the maximum benefit possible from the water — regardless of who initially owns the water!

    d. i. 4 units for User A: $74
    ii. 4 units for User B: $102
    iii. 4 units for User A: $74
    iv. 4 units for User B: $102
    v. 4 units for User B: $102
    vi. 4 units for User B: $102

EXTENSION ACTIVITIES

Government/Law

30. **Explain that some laws and regulations (traffic and zoning laws, pollution regulations, city ordinances) are attempts by the government to ensure that the exclusivity condition of property rights is met.**
31. **Ask students to investigate specific city ordinances and state and federal regulations and relate them to an attempt to minimize the flow of benefits and/or costs to non-owners (or innocent bystanders).**

Economics

32. Ask students to discuss the costs associated with defining and enforcing well-defined property rights over natural resources such as the air, ozone layer, migratory species, and other natural resources.

ACTIVITY 1

DETERMINING THE PRICE AND QUANTITY OF NOTEBOOKS

The market for notebooks made from recycled paper is shown below. These notebooks are valuable to students for taking notes and completing school assignments — plus they are environmentally "friendly." How many of these notebooks are students willing and able to buy at various prices? That amount — the demand for notebooks — is shown below. These notebooks require resources to produce (the recycled paper, processing and cutting machines, workers, energy, etc.). Notebook producers must bid these resources away from other valued uses. If producers are able to cover these costs, they will produce notebooks. How many? The amount the producers are willing and able to produce and offer for sale at various prices — the supply of notebooks — is also shown below. Given this, answer the questions on the accompanying worksheet.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 1 WORKSHEET

DETERMINING THE PRICE AND QUANTITY OF NOTEBOOKS

a. How many notebooks would be purchased at each of the following prices: $20, $10, $7?

b. Why do students buy fewer notebooks as the price rises? (Answer in terms of the value of the notebooks to students.)

c. How many notebooks would be produced and offered for sale at each of the following prices: $15, $7, $5?

d. Why do producers offer more notebooks for sale as the price rises? (Answer in terms of the cost of producing the notebooks.)

e. At what price does the quantity demanded by students equal the quantity producers would offer for sale? Explain why the market would in time establish this as the price of notebooks.

f. The price found in (e) is called the "equilibrium" price. At this price, what is the "equilibrium" quantity produced and purchased?

g. If the demand curve shows the value of each additional notebook, what is the value of the following notebooks: the 10th, the 20th, the 30th, and the 40th?

h. If the supply curve shows the cost of each additional notebook, what is the cost of the following notebooks: the 10th, the 20th, the 30th, and the 40th?

i. If society wishes to maximize the net value (total value minus total costs) it gets from its resources, how many notebooks should be produced?

ACTIVITY 2

THE GUIDE TO IDEAL MARKETS

In order for the market demand curve to reflect the value of a product to society, and the market supply curve to reflect the cost of the product to society, all seven of the following characteristics must exist. If they do, then the equilibrium quantity found by the market is also the quantity which is allocatively efficient. Few real world markets score one hundred percent on these seven characteristics. However, using well-defined property rights and higher degrees of competition in markets as a basis for public policy decisions regarding resource allocation can get us closer to allocative efficiency than if we do not.

Characteristics of Well-Defined Property Rights

Universality
All goods and resources are privately owned and all privileges and limitations with respect to their use are completely specified.

Exclusivity
All benefits and costs related to the ownership or use of all goods and resources accrue only to the owner or by sale to others.

Transferability
All property rights can be exchanged from one owner to another.

Enforceability
All property rights are protected from unauthorized capture or control by others.

Characteristics of a "Competitive" Market

Lack of Economic Power
No buyer or seller in the market is able individually to influence the price established by the market (that is, everyone in the market is a "price-taker").

Free Mobility
All resources can be transferred costlessly into or out of the market.

Perfect Information
Each participant in the market has complete information about the product, including its quality, its price, its ability to satisfy his or her desires, and the availability of substitute products.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

PROBLEMS IN THE NOTEBOOK MARKET

Consider each of the six cases below, looking for reasons why the market for notebooks may NOT yield the equilibrium quantity of notebooks found earlier. Think about how the incentives of buyers to buy and sellers to sell are affected in each case and why the demand and supply curves may not reflect society's actual value or costs.

a. Suppose any notebooks produced must be given to any student who wants them, at no charge.

b. Suppose the de-inking of the recycled paper used in producing the notebooks creates a waste flow that leaks into the local water supply and causes the water to smell bad.

c. Suppose notebook producers and others are not allowed to sell to college students even though college students value the notebooks more highly than high school students do.

d. Suppose the notebook paper is made in such a way that it dramatically reduces the risk of a paper cut to those who handle it (both the students and their teachers).

e. Suppose teachers were allowed to confiscate and keep student notebooks whenever they chose to do so.

ACTIVITY 4

WATER RIGHTS

The first settlements in the western and southwestern parts of the United States were typically located near existing bodies of water. The property rights to the water were generally tied to the land adjacent the water. Called "riparian rights," this definition of rights meant that owners of land next to the water bodies could use the water, but only on the adjacent land they owned.

As long as the demand of these land owners for the water was small relative to its availability, this posed no economic problem (i.e., water was not scarce). However, as the population grew and settled on lands not adjacent to water sources, a change in property rights was needed. Owners of non-adjacent lands needed some means of acquiring water for their lands. The doctrine of "prior appropriation" soon replaced riparian rights.

Prior appropriation gave the rights to use the water to the first person to arrive and claim it. This separated the water rights from the land rights and allowed first claimants to divert water to whoever and wherever they chose. For example, an adjacent land owner could now sell his water to be used by others at other locations. Ultimately, states assumed ownership of all water within their boundaries, and the original claimants were given only use (as opposed to ownership) rights (called "usufructuary rights"). Along with these rights, however, came several restrictions.

One of the first restrictions required that claimants put their water to "beneficial use." If their water was not all being used they faced the prospect of losing their rights to it. In addition, many states established a hierarchy of uses called "preferential uses." For example, agricultural uses might be given first preference, municipal uses (residential uses) second, and industrial uses third. Transfers between the different classes are often restricted. "Instream uses" of water (rafting, fishing, wildlife habitat, etc.) have largely been ignored (consumptive uses are typically given priority).

The lack of direct ownership and the inability of users to transfer water among themselves suggests that water use is likely to be allocatively inefficient.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4 WORKSHEET

The table below shows the benefits received by two users of water (each unit = 1000 gallons). Use this information to answer the questions below.

Amount of Water (units)	Total Benefits Received by User A	Total Benefits Received by User B
1	$20	$30
2	39	57
3	57	81
4	74	102
5	90	120
6	105	136
7	119	150
8	132	162
9	144	172
10	155	180

a. How much value does the 2nd unit of water by itself add to User A's total benefits? _____

What about the 5th unit? _____
... 8th unit? _____
... 10th unit? _____

b. Why might you expect to see the pattern of values indicated in (a)?

c. Suppose 8 units of water are all that is available this year. Determine the total value of benefits generated by this water in each of the following cases:

i. The right to use all units is given to User A with no right to transfer any of the water to others. _____

ii. The right to use all units is given to User B with no right to transfer any of the water to others. _____

iii. User A has been given preferential priority over User B for the first six units of available water in any year while User B is given priority over any other users for the next six units. _____

iv. Same as (iii) but reverse A and B. _____

v. User A has full ownership rights over all units (s/he can use or sell any unit s/he desires). _____

vi. User A and User B each have full ownership rights over one-half of the available water. _____

d. Repeat (c) assuming only 4 units of water are available due to a drought.

WE'RE ALL IN THIS TOGETHER!

INTRODUCTION

When the protective ozone in the upper atmosphere is depleted, we all suffer from increased exposure to ultra-violet rays — whether or not we had anything to do with causing the depletion. If a preservation group buys millions of acres of rain forests, we all benefit from the preserved biodiversity, carbon dioxide absorption, and aesthetic beauty — whether we helped fund this group or not. The ozone layer and rainforests are examples of public goods. In this lesson, students look at the public good quality of many natural resources and the effect of that public good quality on how resources are used.

ECONOMIC CONCEPTS

Public Goods and Services
Shared Consumption
Exclusion Principle
"Free-rider" Problem
Allocative Efficiency

ENVIRONMENTAL CONCEPTS

Ozone Layer
CFCs (chlorofluorocarbons)

OBJECTIVES

- Describe the characteristics of a public good or service.
- Explain why markets tend to undervalue and underproduce public goods and services.
- Explain the "free-rider" problem.
- Describe the public good nature of environmental quality.
- Explain why it is that; regardless of the level of environmental quality, many people will feel that it is not "right" (either too much or too little).

LESSON DESCRIPTION

Students look at case studies involving public products (woodlands and mosquito control). The public character of these products is shown to have an effect on how markets allocate resources. These insights are then applied to the ozone layer and to environmental quality in general.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-8
Day 2: Steps 9-15 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 2, 3, 4, and 5
A transparency of Activity 2

PROCEDURE

Characteristics of a Public Good or Service

1. Distribute a copy of Activity 1 and ask the students to read it.
2. Then lead class discussion, using the questions on Activity 2 (show Activity 2 as a transparency, revealing each question as it is asked). Points for discussion include the following:
   a. Habitat for wildlife species which improves their chance of survival; pleasurable viewing from the scenic lookout; knowledge that at least a small part of the natural environment is preserved.
   b. Primarily homes.
   c. In the case of leaving the woodlands as they are, essentially all those living in Powell. In the case of a housing development, primarily those who live in the homes built. Note that "consuming" the

beauty of the woodlands or "enjoying" the fact that habitat is preserved by one person does not reduce the amount of beauty or habitat the woodlands generate for others. This characteristic of products is called "shared consumption." Note that homes have this characteristic to a much lesser degree since each person living in a house reduces the amount of living space for others.

d. Viewing a scenic area; watching a movie at a theater; the protection provided by the ozone layer; the light from a street light; viewing a fireworks display; national defense; the level of air quality in an area; music at a rock concert.

e. For homes it would be fairly easy. The owners would simply lock others out or call the police if someone attempted to trespass in their home. If the woodlands are preserved it would be very difficult to stop those driving by from seeing the woodlands. Even if a huge wall could be built around them, people still could get the benefit of knowing that the habitat was preserved, even if they didn't pay to preserve it. The woodlands are an example of a good for which an owner cannot easily enforce the "exclusion principle": those who do not pay for a product are excluded from receiving any benefits or value from it.

f. All of those products listed in (d), except watching a movie or music at a rock concert (people are excluded if they don't pay for a ticket).

3. **Finally, tell the class that a good that (A) violates the exclusion principle and (B) has the property of shared consumption is said to be a "public" good. In the story of Mr. Clark, the preservation of the woodlands (habitat preservation, scenic viewing) is a public good, while homes are not.**

How Much is Preserving the Woodlands Worth?

4. **Distribute a copy of Activity 3 to each student. This activity shows the individual values (demand) for preserving acres of the Clark woodlands. It is assumed that there are essentially four types of individuals in the city: those who love the woodlands ("lovers"), those who like the woodlands ("likers"), those who get only a little satisfaction from the woodlands ("so-so-ers"), and those who don't get any satisfaction at all from the woodlands ("don't carers"). The number of each is, respectively: 10,000, 15,000, 10,000, and 5000.**

5. **Ask: How much value would the people of Powell receive from preserving the first 100 acres of the woodlands? Discuss responses.**

   Note that since the woodlands are a public good, everyone receives the benefits of preserving them; society's benefit or value received is therefore the sum of the value received by all the individuals. Each "lover" would receive $10 in benefits (10,000 x $10 = $100,000), each "liker" would receive $6 in benefits (15,000 x $6 = $90,000), each "so-so-er" would receive $3 in benefits (10,000 x $3 = $30,000), and each "don't carer" would receive no benefits. Society's benefits are thus $220,000 ($100,000 + $90,000 + $30,000).

6. **Allow students 10-15 minutes to complete the remainder of the "Society" column and questions a-d, working individually. Answers follow:**

	Society
2nd:	$185,000
3rd:	150,000
4th:	115,000
5th:	90,000
6th:	65,000
7th:	40,000
8th:	30,000
9th:	20,000
10th:	10,000

   a. Assuming each person is motivated by self-interest, she or he would like to see the amount that maximizes the benefit all of them receive. For the "lovers" this is all ten 100-acre units (1000 acres, the entire woodlands), which has a total value to each "lover" of $55 ($10 + $9 + ... + $1). For the "likers" it is 600 acres (total value of $21, $6 + $5 + $4 + $3 + $2 + $1, to each "liker"), for the "so-so-ers" it is 300 acres (total value of $6, $3 + $2 + $1, to each "so-so-er"), and for the "don't carers" it is 0 acres.
   b. None of it — each acre is valued at $800 to produce housing.
   c. This question essentially asks "what is the allocatively efficient level of development?" In other words, what is the most-valued use of each 100-acre unit of the woodlands? Developers are willing and able to pay (i.e., value) $80,000 for each 100-acre unit. The value of preserving each 100-acre unit is given in the "Society" column. The preservation value of each of the first five units exceeds $80,000 (the development value). They should thus be preserved. The remaining units have preservation values less than the development value. They should thus be developed. So, allocative efficiency in this case says that half the woodlands (500 acres) should be preserved and the other half used for a housing development.
   d. 700 acres should be preserved (preserving each of the last three 100-acre units — $75,000; $65,000; and $55,000 — is valued less than the development value of $80,000.)

7. **Conclude this step by asking: Why might it be difficult to find out what people are actually willing and able to pay for preserving these woodlands? Discuss responses.**

   Because the exclusion principle does not apply, people have an incentive to conceal their true willingness and ability to pay for public goods. They know that if others pay to have a public good, the non-payers can not be excluded from enjoying the benefits. This creates a problem for markets that is demonstrated in the next step.

Mosquito Control

8. **Distribute Activity 4. Assign the class working in groups of three or four answer the questions. Discuss responses.**

   a. Clearly, mosquito control is a public service. Everyone in the town will be able to share in the benefits of it, and it would be virtually impossible to exclude someone living in the town from enjoying the benefits even if he or she did not contribute. Given

this, each person has an incentive to try to get the service for nothing or for a very small contribution (hoping everyone else will contribute enough to pay for it). Thus, people tend to understate their true willingness and ability to pay. This is called the "free-rider" problem of public goods and services.

b. Markets would allocate fewer resources to the production of public goods and services because the value (demand) for these would be understated.

Is Everybody Happy? Is Anybody Happy?

9. Ask the class: How many slices of pizza have you eaten in the last month?

   Answers will vary considerably.

10. Ask: Why do the amounts of pizza eaten differ from person to person?

    People's willingness and ability to pay for pizza varies.

11. Returning to the first case study, ask: Can people in Powell each choose different amounts of woodland preservation? Discuss responses.

    No. Woodland preservation is a public good. Everyone must take the same amount of it.

12. Ask: Will the allocatively efficient level of preservation (the level that maximizes the value the community gets from the woodlands) please everyone? Discuss responses.

    No. In fact none of the groups or the developers feel the 500/500 split is the "best." While this allocation is only 100 acres away from the one desired by the "likers" and 200 away from the one desired by the "so-so-ers" (see question (a) of Activity 3), it is likely to leave the "lovers", "don't carers", and the developers disappointed.

13. Note that in contrast to the case of private goods, we can not adjust the amount of a public good to meet each of our own individual preferences. Thus, many people are likely to be unhappy with the level of a public good chosen — no matter what level is chosen

14. Ask: Since environmental quality (e.g., how many parts per billion of some substance is in the air or in a lake; how many acres of scenic forest; how many acres of wildlife habitat; how large is the ozone layer; etc.) is a public good, what does this imply about how people will feel about any level established?

    Many people — perhaps most — will say it is too low or too high. Note that this disagreement is not a result of choosing a level that is not allocatively efficient; it is a result of the nature of environmental quality — i.e., the fact that environmental quality is a public good.

Closure: The Big "O"

15. Ask students to read Activity 5 and to complete the accompanying worksheet. Answers follow:

    a. It is a public good. Whatever level it is and whatever level of protection it provides is the same for everyone (shared consumption). If the level is improved through some means, it would be impossible to withhold the benefits of this improvement from those who might refuse to help pay for the improvement (violates the exclusion principle).

b. It would be less since people have an incentive to behave as "free-riders."
c. Too few would be allocated with respect to the allocatively efficient amount. The demand expressed by people would be less than their true valuation; thus the equilibrium quantity of protection would be less than the allocatively efficient amount.
d. Answers will vary. Most will likely suggest some type of governmental intervention. In fact, many goods and services with public characteristics are supplied in this way (for example: street lights, snowplowing, national defense, and even mosquito control).

EXTENSION ACTIVITIES

Science (Chemistry)

16. Use Activity 5 to discuss the chemical changes that occur in the ozone layer. The "highly reactive chlorine atom" that is broken away from CFC compounds (Cl, referred to as a "free radical") combines with ozone (O3) to form chlorine oxide and oxygen (O2). This is shown in formula form as follows:
Ozone Elimination:
$Cl + O3 \rightarrow ClO + O2$
In addition, it has been discovered that this chlorine free radical could be regenerated with available oxygen so that a single molecule of freon could ultimately eliminate thousands of molecules of ozone. This regeneration occurs as follows:
Regeneration of "Free" Radical:
$ClO + O \rightarrow Cl + O2$
Furthermore, the chlorine oxide generated can also react with ozone and eliminate it as shown by the following:
More Ozone Elimination:
$ClO + O3 \rightarrow ClO2 + O2$
17. Use these equations to demonstrate two important points: first, both sides balance, which confirms the law of conservation of matter (i.e., molecules are not destroyed; they are merely recombined to produce other compounds); and second, that understanding the chemistry of environmental problems is important. (In this case, the cumulative destructive effect, on ozone, of each chlorine atom.)

Math

18. How do scientists know how much ozone will be depleted in the future, given current rates of depletion or decay? Illustrate to students the idea of negative growth ("decay") by starting with the idea of positive growth.
19. Ask: how much money would you have in your bank account one year from today if you earn 5% in interest and the amount you deposit today is $100?
$105 = $100 x 1.05 or $A(1+r)$, where A is the amount you started with and r is the rate of growth.
20. What about two years from today?
$110.25 = ($100 x 1.05) x 1.05, or $A(1+r)^2$.
21. Note that these examples suggest the general formula, $B = A(1+r)^n$, where B is the "future" amount, A is the "current" amount, r is the rate of growth, and n is the number of periods (here, in years). This formula also works if r is negative — that is, if r represents the rate of decay.
5. Letting A = 100 (as in 100%), with r representing the rate of decay, and n

the number of years from today, ask students to determine what percent of the ozone layer would be left (B in the formula), assuming the following scenarios:

a. r = .005 (i.e., 0.50%), n = 50.
b. r = .0015 (i.e., 0.15%), n = 50.
c. r = .01 (i.e., 1%), n = 50.
d. r = .005, n = 100.

The answers to a-d are as follows:

a. $B = 100(1-.005)^{50} = 100(.778) =$ 77.8 (or 77.8% would be left)
b. 92.8%
c. 60.5%
d. 60.6%

Government/Political Science

23. Explain that markets tend to underproduce goods with public good characteristics, and the government thus is often called upon to provide these goods (e.g., national defense, lighthouses, street lighting, street snowplowing, fireworks displays, etc.).
24. Pose the following question to your students: suppose that the amount of each of these goods is decided by majority rule. In particular, suppose the amount supplied is the first quantity that the majority of people say is "enough." How would this quantity compare to that which is allocatively efficient? A possible answer follows:

    It is not likely to be the same, since simple voting does not allow people to express the intensities of their preferences. For example, 51% of the people may want quantity A, while 49% may really want (i.e., value more highly) quantity B. Voting would result in A, while B is more efficient.

ACTIVITY 1

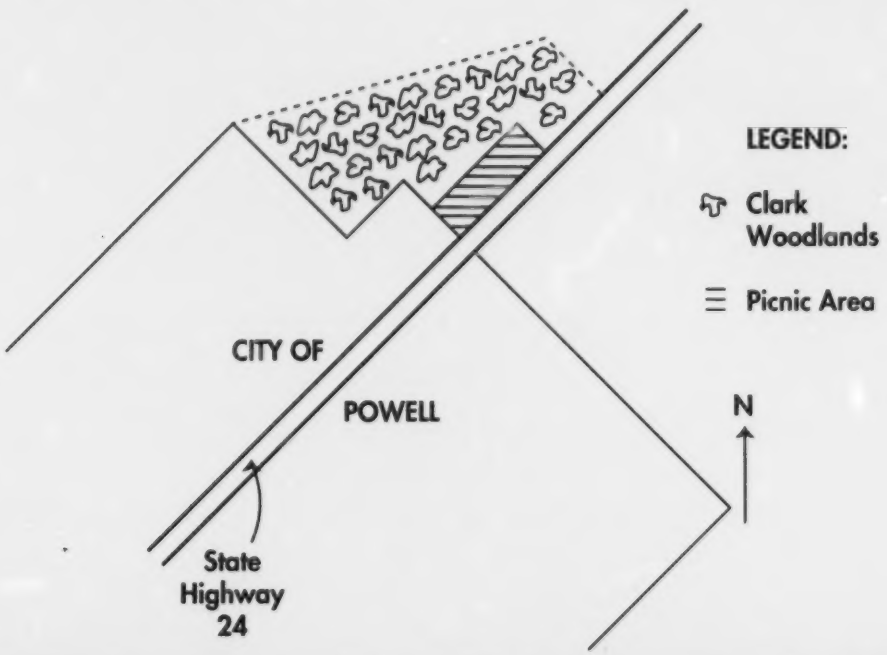
PRESERVE OR DEVELOP?

Mr. Clark owns 1000 acres of natural woodlands in and around Powell, a city with a population of 40,000 (see the map below). Being a long-time nature enthusiast, Mr. Clark has tried over the last 20 years to leave the area virtually unspoiled. It provides a safe haven for many species of wildlife. The main highway into the city passes by the woodlands, and a scenic picnic area off the highway (established and maintained by the city) provides a spectacular view.

The city of Powell itself has been growing over these past 20 years. It has been successful in attracting hi-tech industries primarily because of the natural amenities of the area. As these industries have expanded, so has the need for housing. Mr. Clark's woodlands are seen by housing contractors as an ideal site for future development. In fact, Mr. Clark has been offered $800 per acre by a group representing several local contractors.

Many citizens of Powell are shocked at the prospect of losing part or all of the woodlands to development. They do not wish to give up the valuable amenity services that the woodlands have provided them. A letter signed by more than 100 people is sent to Mr. Clark, asking him to not sell to the contractors. While Mr. Clark is sympathetic to these concerns, he also realizes that the city does need more housing. He ponders over what is really the "best" use of his woodlands.

Complete the worksheet (Activity 2) to help Mr. Clark decide what is the best decision to make if his goal is to provide the most benefits to the citizens of Powell.



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE CLARK WOODLANDS

As an advisor to Mr. Clark, who is trying to determine the best use of the Clark Woodlands for the citizens of Powell, please answer the following questions.

a. If the woodlands are left as they are, what goods and services does society receive from them?

b. If the woodlands are used as space for a housing development, what goods and services does society receive?

c. Who exactly gets the value from the goods and services produced in each of these cases?

d. What are some other goods and services that have the "shared consumption" characteristic?

e. How difficult would it be to exclude those who don't pay for the goods and services from receiving value from them in each of these cases?

f. What are some other goods and services that violate or do not apply the "exclusion principle"?

ACTIVITY 3

WHAT IS PRESERVATION WORTH?

Willingness and Ability to Pay (Demand) for Preserving Acres of the Clark Woodlands					
Acres	Each "Lover"	Each "Liker"	Each "So-so-er"	Each "Don't Carer"	Society
1st 100	$10	$6	$3	$0	____
2nd 100	9	5	2		____
3rd 100	8	4	1		____
4th 100	7	3	0		____
5th 100	6	2			____
6th 100	5	1			____
7th 100	4	0			____
8th 100	3				____
9th 100	2				____
10th 100	1				____

Each of the columns shows the amount that a typical person in that category would be willing and able to pay for additional woodlands preservation. For example, a typical "liker" is willing and able to pay $6 to see that at least 100 acres of the woodlands are preserved and is willing and able to pay another $5 to see that an additional 100 acres is preserved, etc. It is assumed that each person in Powell falls into one of these four groups. Of Powell's population of 40,000, 10,000 are "lovers," 15,000 are "likers," 10,000 are "so-so-ers," and 5000 are "don't carers."

a. What is the minimum amount of the woodlands each of the people represented would say should be preserved?

b. How much of the woodlands do the housing developers feel should be preserved?

c. If Mr. Clark wishes to maximize the value the community receives from the woodlands, how many acres should be preserved? How many developed?

d. What if all of "society's" values (above) were $45,000 greater? Using this new upper limit, answer (c) again.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

DOES ANYONE WANT MOSQUITO CONTROL?

A small town is infested every summer with mosquitos. Many in the town believe that mosquitos are a terrible nuisance at best and potential carriers of disease at worst. An enterprising businessperson senses a real opportunity. "Certainly," she figures, "the willingness and ability of people in this town to pay for a mosquito control program would exceed the cost to me of providing it. I should be able to earn a good profit."

She develops a creative, environmentally-sound control plan of spraying nearby ponds and releasing natural predators to reduce the mosquito population. But alas, when she starts asking people in the town to contribute to putting the plan into effect, she is surprised by how little they offer — many even say they don't wish to contribute at all! Based on these responses, she reassesses the profitability of her idea and decides not to pursue it any further.

a. Assuming her initial estimates of people's willingness and ability to pay were correct, how could you explain the low offers the businessperson received?

b. What does this suggest about the amount of a public good or service that markets would provide if left alone?

ACTIVITY 5

THE BIG "O"

The atmosphere of the earth may be divided into three layers: the troposphere (sea level to around 11 miles above the surface), the stratosphere (from 11 to about 30 miles above the surface), and the mesosphere (beyond 30 miles). About 95% of the earth's total mass of "air," consisting primarily of nitrogen (78%) and oxygen (21%), circulates in the troposphere.

The so-called "ozone layer" lies in the outer two-thirds of the stratosphere. Roughly 99% of the ultra-violet radiation from the sun is absorbed by the small amounts of ozone in this layer. When ultraviolet light strikes ozone molecules it causes them to split apart. But the split molecules quickly reform into ozone and give off infrared radiation (heat). Thus, this layer essentially converts harmful ultraviolet light into heat. This action protects people below from increased sunburning, cancers (particularly skin cancers), and damage to their immune systems, as ultraviolet light is known to be mutagenic and carcinogenic. The conversion of ultraviolet light to heat protects animals and plants in a similar fashion. Intense ultraviolet light is lethal to plants, and smaller doses can still damage leaves, inhibit photosynthesis, and slow growth.

While the flying of supersonic aircrafts (SSTs) and the detonation of nuclear weapons have been linked to ozone depletion (both release nitric oxide which reacts with ozone to form nitrogen dioxide and oxygen), the primary cause is generally agreed to be the use of spray cans and refrigerants that contain freon gas. Freons (also known as CFCs, chlorofluorocarbons) are made up of chlorine, fluorine, and carbon atoms. While it was at first assumed that these gases could safely be released into the atmosphere, it has since been discovered that the ultraviolet light of the stratosphere can break a highly reactive chlorine atom free. This chlorine atom reacts with ozone to form chlorine oxide and oxygen and thus eliminates ozone.

There have been numerous studies over the past two decades in an attempt to determine the degree of ozone depletion. While earlier studies indicated limited depletion, more recent studies indicate annual depletion rates between .15 and .50%. At this rate, half the ozone layer could be depleted by the middle of the 21st century.

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

ACTIVITY 5 WORKSHEET

THE BIG "O"

Answer the following questions based on your reading of THE BIG "O":

a. Is the amount of ozone in the stratosphere a public good or a private good? Explain.

b. How would people's stated willingness and ability to pay for ways to reduce the depletion of the ozone layer compare with what protection of the ozone layer is really worth to them?

c. What does this suggest about the amount of resources that markets would allocate to the protection of the ozone layer?

d. How do you think this problem be handled?

DON'T RAIN ON MY PARADE!

INTRODUCTION

A market system allows people to exercise a great deal of individual control over what goods and services they buy and sell to meet their desires. But what happens when decisions made by one person change the quantity or quality of the products others get? What happens when sulfur dioxide emissions fall as acid rain and harm the forest you enjoy hiking through or the lake where you go fishing? What happens if a country decides to start protecting its rainforest better, thus helping to preserve the habitat of your favorite species? How can we get others to think about how their actions may be affecting us? In this lesson students address these questions through a look at externalities and how they affect the amount of environmental quality we receive.

ECONOMIC CONCEPTS

Externality
Negative externality ("spillover" costs)
Positive externality ("spillover" benefits)
Allocative Efficiency

ENVIRONMENTAL CONCEPTS

pH
Acid Rain

OBJECTIVES

- Identify externalities as "spillover" benefits and costs (externalities).
- Explain why externalities cause markets to produce too much of some products and too little of others.
- Discuss ways to resolve externality problems.
- Explain why resolving an externality problem seldom means eliminating all "spillover" costs or benefits.

LESSON DESCRIPTION

Students play a trading game to learn the economic consequences of trades on the traders and on others who may be affected by the trades. General solutions to externalities are discussed and applied to the problem of acid rain.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-13
Day 2: Steps 14-18 plus any Extension Activities

MATERIALS

One copy for each student Activities 1, 2, 3, and 4.
Trader, observer, and goods cards copied and cut from Activity 1.

PROCEDURE

Being in Control: The Advantages of Trading

1. Divide the class into groups of three, with two traders and one observer in each group. Designate one trader in each group as Trader 1 and the other as Trader 2; give them the appropriate information cards (cut from copies of Activity 1).
2. Next give one-third of the observers an ON card, one-third an OB card, and one-third an OC card.
3. Tell the traders that their objective is to make themselves as happy as they can, where happiness is measured in terms of "utils." They are not to show the other trader their information. Observers may not speak at all during the trading and are not allowed to show their information to the traders.

4. Finally, distribute 5 units of good A to Trader 1 and 5 units of good B to Trader 2 (also cut from copies of Activity 1). Suggest that traders consider one-for-one trades until one or both of them says no.
5. Let the trading begin. Allow 10-15 minutes.
6. Lead class discussion with the following questions:
   a. How much of good A and good B did each trader end up with?
   b. How did the "util" level of each trader change as a result of the trades made?

   The game is constructed so that both traders initially start with 25 utils. Three items should be exchanged during the game, leaving Trader 1 with two units of good A and three of good B. Trader 2 should conversely have two units of good B and three of Good A. This yields each trader 40 utils (each gains 15 utils). Thus, trading results in a 30-util increase in the total happiness of the traders involved. Note that voluntary trades should always lead to an increase in well-being for both traders, as it did here. (If some traders did not obtain this result, ask them to explain why not, and let the other traders in the class explain how they did.)

The Innocent Bystanders

7. Now ask each observer how the trades affected him or her. Discuss responses.

   Those with ON cards were unaffected; those with OB cards gained 60 utils; while those with OC cards lost 25 utils.
8. Ask each group (the traders and the observer) to determine how the total "util" level of the whole group of three was affected by the trades. Discuss responses.

   In the ON cases, the total change is plus-30 utils (the traders' gain only). In the OB cases it is plus-90 utils (the traders' gain plus the observer's 60-util gain). In the OC cases it is plus-5 (the traders' gain minus the observer's 25-util loss).
9. Distribute a copy of Lesson 8, Activity 2 to each student. Note that the table shows the effect of each trade of good A for good B on Traders 1 and 2, and then on each observer for each of the three different cases. The "total change in utils" resulting from each trade for each case is calculated by adding the traders' change in utils to the observers'. Allow students 10-15 minutes to answer the questions; then discuss:
   a. Trades should continue in each case as long as the total change in utils is positive. Thus, in the ON case 3 trades, in the OB case 4 trades, and in the OC case 2 trades. Note that this question is essentially asking what is the allocatively efficient amount of trades, or which amount of trades yields society as a whole (here the traders and their observer) the greatest value (here measured in utils).
   b. The actual number of trades was 3. In the ON case where the observer is unaffected, this amount of trades is the same as what is efficient. In the OB case where the observer benefitted from the trades (received utils), the efficient amount of trades, 4, is greater. In the OC where the observer suffers from the trades (loses utils), the efficient amount of trades, 2, is less.

c. Sum the total change in utils from each trade:
In the ON case (3 trades):
18 + 10 + 2 = 30 utils
In the OB case (4 trades):
43 + 30 + 17 + 4 = 94 utils
In the OC case (2 trades):
13 + 1 = 14 utils

d. In the actual trading only 3 trades were made, thus:
In the ON case:
18 + 10 + 2 = 30 utils (the same).
In the OB case:
43 + 30 + 17 = 90 utils (less).
In the OC case:
13 + 1 - 9 = 5 utils (less).
These are the same values the students found earlier. Note that if the observer is affected by the trades (positively or negatively) and the traders do not take this into account, the amount of utils generated from trading will be less than the maximum that could be attained for the group as a whole.

10. **Summarize this activity by defining externalities and their implications.**
Externalities exist when some of the costs or benefits associated with the production or consumption of a product "spill over" to third parties (the "observers" in the activity). The trading here, for example, may be viewed as that between a producer and a consumer, where good A is some product and good B is money. Positive externalities (spillover benefits) result in too little production or consumption (too little trading in the OB case), because all the benefits generated are not captured in the market demand (here, Trader 2's demand for good A doesn't account for the observer's benefits). Negative externalities (spillover costs) result in too much production or consumption (too much trading in OC case), because all the costs generated are not reflected in the market supply (here, Trader 1's supply of good A doesn't account for the observer's costs).

Resolving an Externality Problem Does Not Necessarily Mean Eliminating All the Spillover Benefits or Costs

11. **Ask students to return to the trading exercise above and once again note where total util gain was the greatest in each situation (3 trades in the ON case, 4 trades in the OB case, and 2 trades in the OC case).**

12. **Given this as society's goal (that is, achieving allocative efficiency), underscore the point that the goal is not achieved by making sure there is no effect on any observer. In the OB case the observer gains 60 utils (although s/he would have liked even more trading). In the OC case the observer still loses 14 utils (although this is certainly better than losing 25, which would have been the case if his/her costs were not considered).**

13. **Resolving externalities (achieving allocative efficiency) involves weighing the benefits and costs of all involved; it is not a matter of making sure no one receives spillover benefits or suffers spillover costs. Ask: what does this imply about "pollution" externalities — pollution costs (damages) which spill over onto third parties? Discuss responses.**
Efficiency may suggest that not all pollution damages should be eliminated, or (in other words) that there is an efficient, non-zero level of pollution (see Lesson 5).

Environmental Externalities

14. Ask students to suggest examples of actions by others which could positively or negatively affect the quantity or quality of the environmental products they receive as innocent bystanders or "observers."

15. Some possible responses are given in Activity 3. Distribute a copy of this activity and add any additional externalities the students have suggested. Then assign the students to complete the activity either in class or as a homework assignment. Discuss results as follows:

a. Emission of sulfur dioxide which creates damaging acid rains.
Traders: energy producers, energy consumers
Spillover Recipients: people who fish in affected lakes, loggers in the affected forests, farmers, people with respiratory problems, owners of corroded structures or soiled textiles
Externality: negative (costs imposed by the acid rain are not reflected in the supply [cost] of energy)
Result: too much energy/sulfur dioxide production

b. Planting of trees and gardens which absorb carbon dioxide and provide beautiful scenery.
Traders: foresters, gardeners, nurseries, land owners
Spillover Recipients: general population, passers-by
Externality: positive (benefits not considered in planters' demand [value])
Result: too few trees and gardens planted

c. The killing of dolphins in tuna nets.
Traders: tuna fishermen, tuna processors, tuna consumers
Spillover Recipients: wildlife lovers, dolphin watchers
Externality: negative (costs not reflected in the supply [cost] of tuna)
Result: too much tuna/dolphin death production

d. The picking up of litter.
Traders: volunteers, garbage bag and glove producers
Spillover Recipients: general population
Externality: positive (benefits of this activity not wholly reflected in demand)
Result: too little litter is picked up and bags and gloves used

e. The establishment of wildlife preserves.
Traders: environmental organizations, governments, land owners
Spillover Recipients: wildlife lovers, preservationists, future generations
Externality: positive (benefits not reflected in the demand for preserves)
Result: too little land is devoted to wildlife preserves

f. The use of CFCs which deplete the ozone layer.
Traders: aerosol and refrigerant users, aerosol and refrigerant producers
Spillover Recipients: general population
Externality: negative (costs due to increased ultra-violet ray exposure not reflected in the supply of these products)
Result: too much production of CFC-using products

g. Emissions of carbon dioxide from automobiles.
Traders: energy users, energy producers

Spillover Recipients: general population and especially coastal dwellers
Externality: negative (costs of global warming not considered by energy producers)
Result: too much energy/carbon dioxide production

Acid Rain

16. **Pose the following problem to the class: Suppose you, a non-smoker, were having a meeting and someone decided to light up a cigarette in the room (assume that smoking is allowed). Ask: Does this act create an externality?**

    Most non-smokers would probably say yes, a negative externality. The smoker is imposing costs on the non-smokers in the form of unpleasant-smelling air, watery eyes, and the potential health damages associated with secondary smoke.

17. **Ask: How has society dealt with this externality?**

    Smoking has been banned in various buildings and areas; smokers have been asked to use smoke-absorbing ashtrays; people have been able to sue smokers and tobacco companies for damages smoking has caused them; cigarettes are taxed so that their price is higher, leading people to buy fewer of them.

18. **Distribute a copy of Activity 4 to each student. Allow them 10-15 minutes to read and answer the questions before discussing their answers in class, as follows:**

    a. A negative externality. The actions of sulfur/nitrogen oxide emitters are imposing costs on people in other regions in the form of recreational, vegetation, material, and health damages, without their consent.

    b. Ban the emission of sulfur/nitrogen oxides altogether; establish and enforce certain types of sulfur emission abatement equipment (such as "scrubbers" to reduce the amount of sulfur emitted); consider class action suits by those harmed by acid rains; charge emitters a tax per ton of sulfur dioxide emitted to provide an incentive for them to reduce their emissions.

    c. Not necessarily. For example, if the damages caused were small and the cost of eliminating or controlling sulfur emissions very large, a large reduction in emissions would not likely be efficient — the energy consumers would be harmed more (due to higher energy prices) than the acid rain recipients would save in damages. On the other hand, if the damages are significant, allocative efficiency would require more control.

EXTENSION ACTIVITIES

Science

19. **Discuss pH as a measure of acidity.**
20. **Ask students to determine the pH of the following items either through research or litmus tests in the lab (typical values are given in the parentheses):**

lemon juice	(2-3)
soft drink	(3)
tomatoes	(4-5)
milk	(6-7)
eggs	(7-8)
baking soda	(9)
milk of magnesium	(10)
oven cleaner	(13-14)
vinegar	(3)

orange juice	(3-4)
coffee	(5)
water	(7)
shampoo	(8)
chlorine bleach	(9-10)
ammonia cleaner	(11-12)
rain water	(3-6)

Geography

21. Describe prevailing wind patterns in your area. Ask students to determine which regions would most likely be responsible for acid deposition in your area and which are most likely to be the recipients of acid deposition from your area.
22. Draw a map showing these areas and the prevailing wind patterns.

Government

23. Explain that externalities are positive or negative side effects that result when the consumption or production of a good or service affects the well-being of people who are not directly involved. Most students do not realize how pervasive externalities are in their everyday lives and how the government has already responded to deal with them in many cases.
24. Ask the students to list some of the externalities they have experienced. Remind them that whenever they get value from something without paying for it or suffer a loss of value without any compensation, an externality has occurred. Discuss the lists as follows:

    Their lists might include seeing an attractive (or unattractive) member of the opposite sex, having their neighbor grow a lovely garden, having someone drive very slowly in front of you, having a factory built next to your house, having your neighbors shovel their sidewalks after a snowstorm, having a noisy party next door, etc.
25. Explain that many laws and regulations (such as traffic and zoning laws, city ordinances, and pollution regulations) are attempts by the government to eliminate or reduce the effect of externalities by specifying limitations on certain behaviors (i.e., by defining property rights more fully — see Lesson 6). Ask students to research actual city ordinances and state regulations and relate them to the concept of externalities.

ACTIVITY 1

TRADER CARDS

Note to the teacher: Duplicate the Trader Information cards below in numbers sufficient for your class. Cut the cards apart on the center line. Distribute.

TRADER 1 INFORMATION				TRADER 2 INFORMATION			
Below is shown the amount of happiness (measured in "utils") that you get from each unit of Good A and B. Your goal is to try to maximize your happiness (your util total) by trading with Trader 2.				Below is shown the amount of happiness (measured in "utils") that you get from each unit of Good A and B. Your goal is to try to maximize your happiness (your util total) by trading with Trader 1.			
A	Utils	B	Utils	A	Utils	B	Utils
1st	9	1st	10	1st	10	1st	9
2nd	7	2nd	8	2nd	8	2nd	7
3rd	5	3rd	6	3rd	6	3rd	5
4th	3	4th	4	4th	4	4th	3
5th	1	5th	2	5th	2	5th	1
(So, for example, two units of Good A would give you 9 + 7 = 16 utils of happiness.)				(So, for example, two units of Good A would give you 10 + 8 = 18 utils of happiness.)			

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 1

OBSERVER CARDS

Note to the teacher: Duplicate the Observer Information cards below in numbers sufficient for your class. Cut the cards apart on the vertical lines. Distribute.

OBSERVER INFORMATION (ON CASE)		OBSERVER INFORMATION (OB CASE)		OBSERVER INFORMATION (OC CASE)	
Below is shown how much your happiness (measured in utils) changes each time Trader 1 trades a unit of good A to Trader 2.		Below is shown how much your happiness (measured in utils) changes each time Trader 1 trades a unit of good A to Trader 2.		Below is shown how much your happiness (measured in utils) changes each time Trader 1 trades a unit of good A to Trader 2.	
Trade	Util Change	Trade	Util Change	Trade	Util Change
None	0	None	0	None	0
1st	0	1st	+25	1st	-5
2nd	0	2nd	+20	2nd	-9
3rd	0	3rd	+15	3rd	-11
4th	0	4th	+10	4th	-13
5th	0	5th	+5	5th	-15
(So, for example, if two units of A are traded, your happiness would not be affected.)		(So, for example, if two units of A are traded, you would gain 25 + 20 = 45 utils.)		(So, for example, if two units of A are traded, you would lose 5 + 9 = 14 utils.)	

ACTIVITY 1

GOODS CARDS

Note to the teacher: Duplicate the Goods Cards below in numbers sufficient for your class. Cut the cards apart. Distribute.

A	A	A	A	A	A
A	A	A	A	A	A
B	B	B	B	B	B
B	B	B	B	B	B

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE EFFECTS OF THE TRADES

The table below shows the change in "utils" resulting from each trade of an additional unit of good A from Trader 1 for an additional unit of good B from Trader 2. It also shows how the "utils" of the observer are affected by these trades in each of the three cases. The "total change in utils" is found by adding the changes for each of the traders to that of the observer in each case. Based on this table, answer the questions below.

Trade	Change in Utils for Trader 1	Change in Utils for Trader 2	Change in Utils for ON Observer	Total Change in Utils for ON Case	Change in Utils for OB Observer	Total Change in Utils for OB Case	Change in Utils for OC Observer	Total Change in Utils for OC Case
1st	+9	+9	0	+18	+25	+43	-5	+13
2nd	+5	+5	0	+10	+20	30	-9	+1
3rd	+1	+1	0	+2	+15	+17	-11	-9
4th	-3	-3	0	-6	+10	+4	-13	-19
5th	-7	-7	0	-14	+5	-9	-15	-29

a. Determine the amount of trading that would yield the largest gain in utils for the group as a whole (traders plus the observer) in each of the three cases.
ON case: _____ trades
OB case: _____ trades
OC case: _____ trades

b. How does the amount of trades in (a) compare with the actual amount that took place?
ON case:
OB case:
OC case:

c. What is the total change in utils that is received from the number of trades given in (a)?
ON case: _____ utils
OB case: _____ utils
OC case: _____ utils

d. How does the amount of utils received in (c) compare with the amount received from the actual trading?
ON case:
OB case:
OC case:

ACTIVITY 3

ENVIRONMENTAL EXTERNALITIES

For each of the situations listed below: (1) identify who the "traders" are, (2) identify who the "observers" or spillover recipients are, (3) tell whether the externality is positive or negative, and (4) tell whether too much or too little of the activity is probably occurring as a result of the externality.

a. Emission of sulfur dioxide which creates damaging acid rains.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

b. Planting of trees and gardens which absorb carbon dioxide and provide beautiful scenery.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

c. The killing of dolphins in tuna nets.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

d. The picking up of litter.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

e. The establishment of wildlife preserves.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

f. The use of CFCs which deplete the ozone layer.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

g. Emissions of carbon dioxide from automobiles.
   Traders:
   Spillover Recipients:
   Externality:
   Result:

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

ACID RAIN

The burning of coal and oil creates many gases and particulates, including sulfur and nitrogen oxides. When these are emitted from tall smokestacks (typically installed so that local air quality standards could be met), winds can transport them over great distances. In the course of wind-borne travel they can combine with water vapor in the air to form droplets containing sulfuric acid and nitric acid. These droplets then fall back to the Earth in the form of rain or snow, or they linger in the air as fog. This deposition of acids is commonly referred to as "acid rain."

The area in which acid rain falls can suffer numerous effects depending on its natural ability to neutralize these acids. As the acidity of a lake increases it kills fish, aquatic plants, and many microorganisms. As the acidity of soil increases it can stunt crop growth and damage tree roots. The acids also can result in material damage such as corroding metals, discoloring concrete and stone structures, and soiling textiles. Increased acidity in the air can aggravate human respiratory diseases and directly damage the needles and bark of conifer trees.

The acidity of substances in water solutions is measured in terms of pH (the concentration of hydrogen ions). A solution with a pH of 7 (pure water) is called neutral. Acidic solutions have pHs less than 7 while those with pH values greater than 7 are called basic. Normal rainfall has a pH between 5 and 5.5 (so even "clean" rain is slightly acidic). In the eastern U.S., rainfall averages around 4.3, with some areas reporting around 3. Note that each whole-number decrease in pH represents a ten-fold increase in acidity.

Because acids are deposited "downwind," the damages suffered in a given area are typically not the result of sulfur and nitrogen oxides generated in that area; instead, the acids probably originate in a region "upwind." It has been established, for example, that the vast majority of acid deposition in the Scandinavian countries comes from countries in Europe. Similarly, most acid deposition in southeastern Canada and the northeastern United States has been traced to emissions from states in the industrialized upper Midwest (such as Ohio and Indiana).

Questions

a. Is acid rain a positive or negative externality? Why?

b. How could solutions used with respect to smoking be applied to acid rain?

c. Are these solutions allocatively efficient? That is, does society as a whole get the most value from the solution?

UNIT 4

FINDING SOLUTIONS WHEN MARKETS CANNOT

WEIGHING THE PLUSES AND MINUSES: BENEFIT-COST ANALYSIS

INTRODUCTION

When the market for a product is "ideal," all the benefits society receives from it are reflected in its demand curve and all the costs associated with its production and use are reflected in its supply curve. Benefit-cost analysis attempts to replicate this result when markets are not ideal, in order to determine what quantity is most desirable to produce. This is particularly important for products that don't pass through markets — such as a walk in the local park, clean air, a scenic view, or ultra-violet ray protection. In this lesson students learn how benefit-cost analysis attempts to find the "right" amount of non-marketed products to produce.

ECONOMIC CONCEPTS

Allocative Efficiency
Benefits
Costs
Net Value
Present Value
Benefit-Cost Analysis

ENVIRONMENTAL CONCEPTS

Amenity Services

OBJECTIVES

- Explain the purpose of a benefit-cost analysis.
- Describe benefits and costs.
- Calculate the present value of future benefits and costs.
- Conduct a simple benefit-cost analysis.
- Assess the limitations of benefit-cost analysis.

LESSON DESCRIPTION

By analyzing a decision that may be very familiar to them — studying versus playing a game — students are introduced to the idea of weighing benefits and costs. The concepts are then applied to a case study of a typical environmental problem: emissions control. Students consider the benefits and costs of this sort of control and how the timing of these benefits and costs affects their present value. Limitations of benefit-cost analysis are discussed before the lesson culminates with a look at a classic application of benefit-cost analysis: the damming of Hell's Canyon.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-5
Day 2: Steps 6-20 plus any Extension Activities

MATERIALS

Dollar bill and $1.00 in pennies
One copy for each student of Activities 1, 2, 3, 4, and 5
A transparency of Activity 3

PROCEDURE

The Test or the Quest: Which is the Best?

1. Distribute a copy of Activity 1. Allow students 10-15 minutes to complete it.
2. Discuss answers as follows:
   a. Play "The Quest," since it yields a greater amount of satisfaction (112 utils versus 105).
   b. Benefit: likely grade rises from F to D: gain of 30 utils
   Cost: doesn't reach the 13th

level — loss of 6 utils
Net Value: 30 - 6 = 24 utils

c. For second study hour:
Benefit: likely grade rises from D to C: gain of 25 utils
Cost: doesn't reach the 12th level — loss of 8 utils
Net Value: 25 - 8 = 17 utils
For third study hour:
Benefit: likely grade rises from C to B: gain of 20 utils
Cost: doesn't reach the 11th level — loss of 10 utils
Net Value: 20 - 10 = 10 utils
For fourth study hour:
Benefit: likely grade rises from B to B+: gain of 15 utils
Cost: doesn't reach the 10th level — loss of 13 utils
Net Value: 15 - 13 = 2 utils
For fifth studying hour:
Benefit: likely grade rises from B+ to A-: gain of 10 utils
Cost: doesn't reach the 8th level — loss of 25 utils
Net Value: 10 - 25 = -15 utils
For the sixth studying hour:
Benefit: likely grade rise from A- to A: gain of 5 utils
Cost: doesn't reach the 6th level — loss of 50 utils
Net Value: 5 - 50 = -45 utils

d. Four hours of studying and two hours of playing — up through the first four hours of studying the net value gained was positive; beyond there (the 5th and 6th hours), it was negative.

e. (0,6): 112 (0 + 112)
(1,5): 136 (30 + 106)
(2,4): 153 (55 + 98)
(3,3): 163 (75 + 88)
*(4,2): 165 (90 + 75), the greatest amount of satisfaction
(5,1): 150 (100 + 50)
(6,0): 105 (105 + 0)

Beau Crat and Benefit-Cost

3. Introduce this part of the lesson by explaining that, just as Zach tries to determine the "right" amount of studying, society has to decide on the "right" level of air or water quality to produce. This in turn requires that society must find the "right" amount of emissions to allow into the air or water. What is meant by the "right" amount? Discuss answers as follows:
   Remind students that there are many definitions of right amount, depending upon the criteria used. Economists often define the right amount of a product in terms of allocative efficiency: the right amount of a product is that quantity that yields society the most net value. Net value is the benefits received minus the costs incurred. Emphasize that this is the same basic criterion people use every day in deciding what is "best" for them (as Zach did in Activity 1).
4. Distribute a copy of Activity 2. Ask students to read the story and answer the questions. Allow 5-10 minutes and then discuss their responses as follows:
   a. Less risk of death or illness, improved aesthetics — they get more of the product, environmental quality (the flow of life-support and amenity products from the natural resources of the environment).
   b. Does not have to install or operate control equipment. Thus society can use the resources to produce this equipment to produce other valuable products.
   c. Allocative efficiency.
5. Show a transparency of Activity 3. Discuss the general nature of the figures shown:

Note that the benefits of each additional 20% control tend to fall (for example, the second 20% adds $300,000 to benefits, while the last 20% adds only $25,000—see Lesson 3) and that the costs of each additional 20% control tend to rise (for example, the second 20% adds $1,000,000 to costs, while the last 20% adds $8,000,000 — see Lesson 4). Students may also question using $100,000 or any other sum of money as the value of a life — see Lesson 11 for a discussion of this issue. The point here is that benefit-cost analysis attempts to identify and quantify all the benefits and costs of a particular activity.

Present Value

6. Note that the benefits and costs of some things (such as emissions control in the case above) accrue in the future. Ask: Should these be valued the same as, more than, or less than benefits and costs incurred today? Why? Discuss answers.
7. Place a dollar bill and a dollar's worth of pennies in full view of the class. Select three or four students to "help you with an experiment," while the rest of the class observes. Tell the student assistants that each of them has the choice of taking all the pennies now or the dollar bill on the last day of class. (Most students will choose the 100 pennies.)
8. Then start removing a penny or two at a time from the pile of pennies, each time asking the students if they still want to choose the remaining pennies now, over the dollar later. Continue removing pennies until one of the students chooses to wait and get the dollar later. Record on the board the number of pennies left when this decision occurs.
9. Continue with the other students, noting how many pennies were left before each decided to wait and take the dollar.
10. Ask the students to return to their seats; then ask the class what this activity demonstrates about the present (or current) value of a dollar compared to the value of a dollar received on the last day of class. Discuss answers as follows:

    It is valued less highly than a dollar received today, since students are willing to take less than a dollar today (the pennies) and still feel they are better off. The exact present value for each student may be determined by when each one decided to wait for the dollar. For example, if a student first decides to wait for the dollar after 60 pennies are left, then the present value of the future dollar is about 60 cents.
11. Ask the participating students: why were you willing to take less?

    Possible responses: unsure that the teacher will remember to pay them the dollar on the last day of class; need the extra money right now to buy something; the old adage "a bird in the hand is worth two in the bush" (be happy with what you have already); or the opportunity cost possibility discussed below.
12. Next ask students: how much would you be willing and able to pay now for some software worth $100 to you today, if you would not actually get the software until one year from today? Why?

    Most will say they would pay less than $100, for the same reasons given in the experiment.

13. Reinforce the economic concept that the software's present value is less than its future value. Then suggest, or pick up on the student's suggestion if given above, that another reason for this behavior has to do with the opportunity cost of the payment now. Relate the following to the students: By paying today you would lose (forgo) the opportunity of earning interest on, or doing something else with, your $100 during the coming year. If the interest rate is 8%, for example, that means you would actually end up paying $108 ($100 plus $8 lost interest) for software you value at only $100 and won't get to use until one year later. To make it worthwhile to pay today, your payment should be less than $100, to account for the opportunity cost (lost interest). It is possible to calculate how much less than $100 your payment should be.
(Note to teacher: If your students have facility with mathematics, this is an excellent opportunity to show them how a simple algebraic equation can be used to compute these values.)
14. Write this problem on the board as "P + rP = $100" where P is the payment, r is the rate of interest for one year (so that rP is the interest lost), and $100 is the expected future value of the current payment. Now factor the terms to solve for P. The equation may be written as "P (1+r) = $100", and then "P = $100/(1+r)". Thus, if r = 8%(.08), P would be roughly equal to $92.60. So, $92.60 is the most you should be willing to pay today for a $100 value received a year from today. This number is called the "present value," or PV, of $100, the future value to be received a year from today. Note, as we would expect from above, that it is less than $100. Applying the same line of reasoning for subsequent years yields the following present value formula:

$$PV = FV/(1+r)^n,$$

where PV is the present value of a benefit or cost (FV) received n years from today if the interest rate is r.
15. Distribute a copy of Activity 4 and have the students complete it. If your students have calculators, they should use them here. Some students may not be familiar with exponents. Remind them that the "n" is the number of times the term it is next to must be multiplied by itself. For example, $(1+r)^3 = (1+r) \times (1+r) \times (1+r)$. Activity 4 answers follow:
    a. i. $500/(1.05)^2 = \$453.51$
    ii. $500/(1.02^2 = \$480.58$
    iii. $500/(1.05)^4 = \$411.35$
    iv. $500/(1.04)^2 + 500/(1.04)4 = 462.28 + 427.40 = \$889.68$
    v. $500/(1.1) + 500/(1.1)2 + 500/(1.1)^3 + 500/(1.1)4 + 500/(1.1)^5 = 454.54 + 413.22 + 375.66 + 341.51 + 310.46 = \$1895.39$
    b. As the interest rate rises, the present value of a future value decreases. In other words, as the interest rate used rises, future values are given less weight.
    c. The further in the future a value is to be received, the less is its present value.
    d. $200,000 + 200,000/(1.06) + 200,000/(1.06)^2 + 200,000/(1.06)^3 + 200,000/(1.06)^4 = 200,000 + 188,679.24 + 177,999.29 + 167,923.86 + 158,418.73 = \$893,021.12$
    e. $1,000,000/(1.08)50 = \$21,321.23$
    f. Using present value (i.e., discounting future costs) tends

to encourage decisions and actions which have large current benefits and costs (even if they are large) which accrue in the distant future. Conversely, the use of present value tends not to encourage decisions or actions with high current costs and benefits which accrue in the future.

Helping Beau to Make a Decision

16. Distribute a copy of Activity 5. This activity shows the present value of the benefits and costs of emissions control for various levels of control, plus interest rates (based on the assumptions and values given in Activity 3).
17. Ask students to do these tasks:
    a. Construct a net present value table (or provide them with one for analysis — see answer below).
    b. Determine the allocatively efficient level of control for each interest rate.

    Answers to a and b:
    a. Net present value = the present value of the benefits minus the present value of the costs for each entry as shown below:

Net Present Value (present value in millions of $) Amount of Emissions Control					
r	20%	40%	60%	80%	100%
1%	35.9	62.1	62.5	49.6	28.6
3%	9.4	15.7	8.2	(7.3)	(29.1)
5%	4.2	6.7	(2.0)	(17.6)	(38.8)
10%	0.6	0.3	(8.7)	(23.2)	(43.0)
20%	(1.0)	(2.2)	(10.2)	(22.8)	(39.5)

    b. Allocative efficiency occurs at that level of control where net present value is maximized: for r = 1%, 60% control; for 3%, 40% control; for 5%, 40% control, for 10%, 20% control; for 20%, 0% control (all other levels generate negative net benefits).

Limitations

18. Ask students why some people might question doing such an analysis. Discuss the following:
    a. There may be other, more important criteria than allocative efficiency (see Lesson 5, Procedure 1).
    b. Estimation of the values (value of a life, value of clean air) in question may be difficult, since these values cannot be directly observed in markets. In addition, people may simply not have enough information to estimate a value for something such as biodiversity, clean air, or the ozone layer (see Lessons 3, 10, and 11).
    c. Distribution of the benefits and costs may not be "fair." A policy which increases a wealthy person's benefits by $1000 while it imposes costs of $100 on nine poor people is allocatively efficient (net value is positive), but is it really still desirable?
    d. What is the appropriate interest rate to use? The higher the rate used, the less future benefits and costs "count." Is it "fair" to future generations to weigh their benefits and costs differently than our own?

The Damming of Hell's Canyon

19. Relate the following to the class: A well-documented example of the use of benefit-cost analysis involved the proposed building of a hydroelectric

dam and its accompanying reservoir on a scenic portion of the Snake River on the Idaho-Oregon border. Known as Hells Canyon, this area was not only an extraordinary natural environment but also an ideal site for dam construction, given the volume of water flowing in the river and the narrowness and steepness of the canyon (a complete description of this case may be found in *The Economics of Natural Environments*, by John Krutilla and Anthony Fisher).

20. Suppose the only question in this case had been whether or not to build a dam at a particular site. Divide the class into two groups. Ask one group to identify as many benefits as they can from building the dam. Ask the other group to do the same for the costs. Also ask both groups to discuss the timing of these benefits and costs (current, future, distant future, etc.). Discuss answers as follows:

    Potential benefits: increased recreational opportunities on the reservoir; reduced costs to produce electricity; flood control.

    Potential costs: dam construction costs; maintenance and operating costs of the dam; reduced recreational activities in the canyon; habitat loss.

EXTENSION ACTIVITIES

Economics

21. Assign students to find and report on an actual case involving a benefit-cost study. Newspaper articles or letters to state or federal legislators are good places to start. An executive summary of the study should provide answers to the following basic questions: What was the nature of the problem? What was the objective of the study? What benefits and costs were identified? How were they measured? What was the conclusion of the study?

Government/Political Science

22. Continue the activity above by investigating what impact, if any, the studies had on the actual policy decisions. A good place to start would be a phone call or letter to the principal investigators or authors of the study in question. Students should ask exactly how the study was used, who used it, and whether any policy change occurred or did not occur because of it.

Math/Economics

23. For extra credit, assign students to derive one of the values given in one of the tables of Activity 5 from the information given in Activity 3.

ACTIVITY 1

THE TEST OR THE QUEST: WHICH IS BEST?

Zach has a test in algebra tomorrow. The more practice problems he does tonight, the better he will do on the test. The better he does on the test, the better he will feel (feeling of personal accomplishment, less hassle from his parents, better chance for a good-paying technical job in the future, etc.). On the other hand, Zach also loves to play "The Quest," the latest video game he has purchased for his home computer. The game has incredible graphics and 20 levels of action. Zach has only made it through the first four levels, but with more time he could go further. The more he plays, the more he advances, and the more enjoyment he gets. He plans to fill the six hours he has before going to bed with only these two activities. The table below shows the amount of satisfaction (measured in "utils") Zach could get from each activity tonight. Based on this, answer the questions below.

	If Hours Spent Studying for the Test		If Hours Spent Playing "The Quest"	
Number of Hours	Likely Grade	Satisfaction (in Utils)	Likely Level	Satisfaction (in Utils)
0	F	0	4th	0
1	D	30	6th	50
2	C	55	5th	75
3	B	75	10th	88
4	B+	90	11th	98
5	A-	100	12th	106
6	A	105	13th	112

a. If Zach were to spend all six hours doing only one of these two activities, which activity would he choose? Why?

b. What is the benefit and cost to Zach of the first hour of studying? What is the net value (benefit minus cost)?

c. Answer the questions in (b) for the second through sixth hours of studying.

d. Based on (c), how much studying and how much playing should Zach do to maximize his total satisfaction?

e. Verify your answer in (d) by calculating the total amount of satisfaction Zach receives from each of the following:
0 hours of studying, 6 hours of playing: _____ utils
1 hour of studying, 5 hours of playing: _____ utils
2 hours of studying, 4 hours of playing: _____ utils
3 hours of studying, 3 hours of playing: _____ utils
4 hours of studying, 2 hours of playing: _____ utils
5 hours of studying, 1 hour of playing: _____ utils
6 hours of studying, 0 hours of playing: _____ utils

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

BEAU CRAT AND BENEFIT - COST ANALYSIS

Beau Crat, a somewhat inept official in a state regulatory agency, is faced with a perplexing problem. As a local factory increases its emissions of "traf," nearby residents become concerned about the reduced aesthetic quality of their neighborhood, as well as possible health effects (traf emissions have been linked to a rare form of deadly cancer). A representative from the neighborhood, Mr. Resident, asks Beau to help by forcing the factory to clean up all its emissions.

However, the factory's owner, Mr. Bean, argues that installing and operating the necessary equipment to control his emissions would simply be too costly — especially if he is forced to control 100% of his emissions. He says it would likely put him out of business. Beau must determine what should be done. He enlists the aid of the state economist, Milton Samuelson, who suggests conducting a benefit-cost analysis. Samuelson argues that the issue is how the air around the factory should best be used: as a depository for Mr. Bean's traf emissions or a source of environmental quality for the neighborhood residents. He tells Beau he must weigh the value of increased emissions control (that is, the value of improved environmental quality) against the cost of achieving it (that is, the cost of controlling the emissions), to determine the "right" amount of emissions control.

a. What benefits do the neighborhood residents receive from emissions control?

b. What benefits does Mr. Bean receive from being able to use the air as a depository for his traf emissions?

c. What criterion is Milton Samuelson using to decide the "right" amount of emissions control (which decides how the air should be used)?

ACTIVITY 3

BEAU'S BENEFIT AND COST ASSUMPTIONS AND ANNUAL VALUES

BENEFITS

The principal benefits are deaths avoided and improved aesthetics. These benefits begin to appear after a three-year period needed to construct the necessary control facilities, and then they go on basically forever.

Reduction in Traf Emissions	Deaths Avoided	Value of Deaths Avoided*	Value of Increased Aesthetics	Total Annual Benefits
0%	0.0	$0	$0	$0
20%	2.5	$250,000	$250,000	$500,000
40%	4.2	$420,000	$380,000	$800,000
60%	4.7	$470,000	$455,000	$925,000
80%	4.9	$490,000	$485,000	$975,000
100%	5.0	$500,000	$500,000	$1,000,000

*Assuming the value of a statistical life is $100,000.

COSTS

Construction costs depend upon the level of control, as noted in the table below. Operating costs of the control equipment are assumed to be $100,000 per year, regardless of the level of reduction chosen; operating costs begin to accrue after construction is completed (three years.)

Reduction in Traf Emissions	Annual Construction Costs
0%	$ 0
20%	$ 1,000,000
40%	$ 2,000,000
60%	$ 6,000,000
80%	$ 12,000,000
100%	$ 20,000,000

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

PRESENT VALUE

a. Determine the present value of each of the following, using the present value formula:

$$PV = FV/(1+r)^n$$

i. $500 received two years from today with an interest rate of 5%.
ii. $500 received two years from today with an interest rate of 2%.
iii. $500 received four years from today with an interest rate of 5%.
iv. $500 received two years from today plus another $500 received 4 years from today with an interest rate of 4%.
v. $500 received at the end of each of the next five years with an interest rate of 10%.

b. Compare (i) and (ii) above and draw a general conclusion.

c. Compare (i) and (iii) above and draw a general conclusion.

d. You have just won a $1,000,000 lottery! You will be paid $200,000 today and then $200,000 in each of the four following years. With an interest rate of 6%, what is the present value of your lottery win?

e. What is the present value of $1,000,000 received 50 years from today with an interest rate of 8%?

f. Given that many environmental costs are likely to fall quite a few years in the future (global warming, ozone depletion, etc.), what is the implication of "e," above, for how the use of present value affects the "importance" of these costs today?

ACTIVITY 5

BEAU'S BENEFIT-COST TABLES

Table A. BENEFITS (present value of benefits in millions of $)
Amount of Emission Control

r	20%	40%	60%	80%	100%
1%	48.5	77.7	89.8	94.6	97.1
3%	15.3	24.4	28.2	29.7	30.5
5%	8.6	13.8	16.0	16.8	17.3
10%	3.8	6.0	7.0	7.4	7.5
20%	1.4	2.3	2.7	2.8	2.9

Table B. COSTS (present value of costs in millions of $)
Amount of Emission Control

r	20%	40%	60%	80%	100%
1%	12.6	15.6	27.3	45.0	68.5
3%	5.9	8.7	20.0	37.0	59.6
5%	4.4	7.1	18.0	34.4	56.2
10%	3.2	5.7	15.7	30.6	50.5
20%	2.4	4.5	12.9	25.6	42.4

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

MEASURING THE VALUE OF ENVIRONMENTAL PRODUCTS

INTRODUCTION

The economic value of products is based on what people are willing and able to pay for them (see Lesson 3). If you wanted to know how much apples are worth you could simply go to a market where apples are sold and observe the transactions, noting people's reactions to different prices. If they pay $1 for an apple, then it must be worth at least that much to them. Unfortunately, there are no markets for many environmental products, such as improvements in air quality, mercury-free fish, scenic canyons, or the preservation of a rare species. Why "unfortunately"? Because knowing how much society values these products is crucial to people as they try to determine how to allocate resources between marketed and non-marketed products. In this lesson students look at some ways in which values for environmental products can be estimated.

ECONOMIC CONCEPTS

Non-marketed Products
Substitutes
Value
Demand
Contingent Valuation

OBJECTIVES

- Define a product's value and relate it to the demand for the product.
- Describe how the markets for marketed products may be used to estimate the value of non-marketed, environmental products.
- Estimate the value of an environmental product using a survey approach.

LESSON DESCRIPTION

The lesson reviews the definition and measurement of value. Students are asked to estimate the value of improved air quality based on the effects of this improvement in various markets. Then students construct their own survey to determine the value of an improvement in local environmental quality by directly asking people about their willingness and ability to pay for the improvement.

TIME REQUIRED

One class period:
Steps 1-8
Parts of four class periods:
Step 9

MATERIALS

One copy for each student of Activities 1, 2, and 3
Questionnaires

PROCEDURE

Value and Demand

1. Review the economic meaning of value and its relationship to a product's demand (see Lesson 3). Emphasize that value is defined by people's willingness and ability to pay. This may be estimated by observing the demand expressed for a product in a market. If 10 units are purchased at a price of $10 and 11 units are purchased at a price of $9, then one can conclude, for example, that the value of the 11th unit is at least $9, but less than $10. Continuing in this manner, the value of each unit of a product could be estimated.

Products Without Markets

2. Ask the following rhetorical questions: Where can I go to buy some better air quality for U.S. cities? Where do I go to get more ozone for the ozone layer? Whom do I have to see to rent part of the ocean for a whale preserve? Are these things available at the mall? Why not? Discuss responses.

   Note that a market requires both buyers and sellers. While people are certainly willing and able to pay for these things (there are buyers with demand), the problem is that no one is able to supply them! The amount of these products is not under anybody's individual control, so nobody is in a position to offer them for sale. Without sellers there is no market, and without a market there is no market activity which we may observe to estimate the value of these products. This leaves essentially two ways of finding these values: *indirectly*, by observing effects in other markets; or *directly*, by asking people what they would be willing and able to pay.

Indirectly: Observing Effects in Other Markets

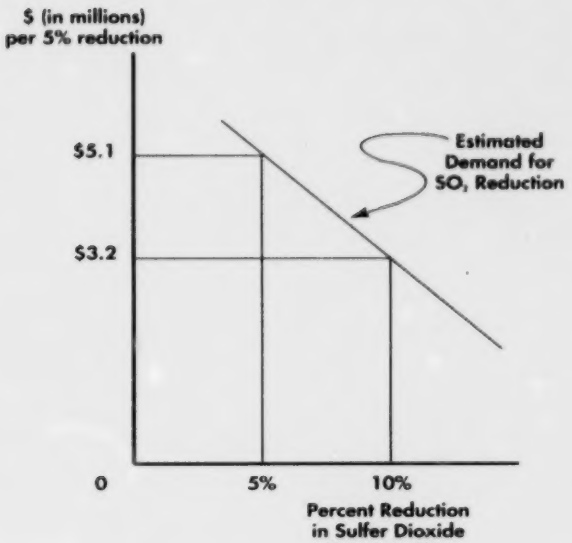
3. Distribute a copy of Activity 1 to each student. Ask students working in small groups to complete this activity. Allow them 10-15 minutes. Discuss their responses in class.
4. Now distribute a copy of Activity 2 to each group. This activity describes some ways in which economists have used market information to estimate the value of some environmental products. Compare these methods with the students' suggestions. Have the groups complete Part 2 of Activity 2, using the information from Part 1. Allow 15 minutes and then discuss the answers, as follows:

---

a.	For first 5% reduction:	$400,000 ($40 x 10,000).
	For next 5% reduction:	$200,000 ($40 x 5,000).
	Total for 10% reduction:	$600,000
b.	For first 5% reduction:	$1,000,000 ($3.5m - $2.5m)
	For next 5% reduction:	$500,000 ($2.5m - $2.0m)
	Total for 10% reduction:	$1,500,000
c.	For first 5% reduction:	$2,500,000 ($500m x .005)
	For next 5% reduction:	$2,000,000 ($500m x .009 - $2.5m)
	Total for 10% reduction:	$4,500,000 ($500m x .009)
d.	For first 5% reduction:	$1,200,000 ($2m - $1m plus [$500,000 - $300,000])
	For next 5% reduction:	$500,000 ($1m - $600,000 plus [$300,000 - $200,000])
	Total for 10% reduction:	$1,700,000
e.	For first 5% reduction:	$5,100,000 (sum of a-d)
	For next 5% reduction:	$3,200,000 (sum of a-d)
	Total for 10% reduction:	$8,300,000

f. Plot the points: (5%, $5.1m) and (10%, $3.2m) using "the percentage reduction in sulfur dioxide" on the horizontal axis and "dollars per 5% reduction" on the vertical axis. Connect the points to form the demand curve for reductions in sulfur dioxide levels. Note that the curve shows the value of each 5% reduction (the first is $5.1m, the second is $3.2m, etc.). The total value of a 10% reduction is determined by adding the values of the first two 5% reductions.

See graph below. Note that this curve is downward-sloping as is suggested by the discussion in Lesson 3.



5. Ask students to discuss how this method could be used to determine the value of other environmental products. Some examples follow.

Protecting an endangered species: consider contributions to environmental organizations such as the Nature Conservancy, which uses funds to buy habitat or to lobby for protection; consider people's demand to visit zoos (a substitute for viewing animals in the wild);

Ozone layer protection: consider the medical costs saved from fewer skin cancer cases; consider the lower expenditures on skin protection lotions;

Visiting a wilderness area: estimate the out-of-pocket travel expenses (gas, lodging, etc.) plus time costs to get there (people must value the site at least this much or they wouldn't incur the expenses).

Directly: Just Ask People

6. Explain that the most direct way to get an estimation of people's willingness and ability to pay for an environmental product is to ask them. This idea goes by the name of "contingent valuation" because people are asked how they would behave if a market did exist where they could buy a particular environmental product.
7. Relate the following examples:
"How much would you be willing and able to pay to:
...preserve the current habitat of grizzly bears?"
...reduce the amount of particulates in the air by 10%?"
...create a new wilderness area?"
...improve water quality to enhance sport fishing?"
...stop further depletion of the ozone layer?"
...have better visibility (clearer vistas)?"
...clean up a local hazardous waste site?"
8. Discuss with the students how they would respond to the last question if

they were given all the details about the nature of the wastes, the damages they might possibly cause, and the cost of cleaning up the site. Ask each student to estimate the dollar amount that they would actually be willing and able to pay. Then ask: Why might people's answers to questions such as these be open to criticism? Discuss the responses as follows:

The difficulty students encounter in coming up with a value should suggest the following problem: the situation is hypothetical and the "market" is unfamiliar — people just don't think of these environmental outcomes as products that can be bought and sold. Yes, they are valuable, but how does this value compare to the value one would receive from buying a new car or going to a movie? A second problem is that people may simply misrepresent their true willingness to pay, since the whole thing is hypothetical anyway. They may not take the question seriously and simply give a number "off the top of their head" or say what they think the person asking the question wants to hear. Respondents could vastly overstate their actual willingness and ability to pay since it is likely they won't ever have to pay what they say they would.

Contingent Value Survey

9. Assign the class to conduct a contingent value study to determine the value of some environmental product. The following provides a plan the class could use:
   a. Pick the topic (Day 1). Ask the class to choose an environmental product (or a change in environmental quality) they are interested in placing a value on. While broad environmental issues may be considered, suggest that the class choose a fairly specific local topic. For example: cleaning up a particular hazardous waste site, preserving a specific natural area or park, planting trees along certain streets, cleaning up graffiti on local buildings and roadways, improving local recycling efforts, etc.
   b. Design a questionnaire (Day 1). This should include a very specific description of the product in question (so people know exactly what they are attempting to put a value on), a basic contingent valuation question and background information about the respondents (the background information may be used in an analysis of factors affecting the values people assign). Activity 3 provides a sample questionnaire which can be distributed to the students.
   c. Select a target (or "population") group to be sampled (Day 1). While the class might consider using the whole city or town, it would be easier to confine the study to the school. Once the target group is identified, the class needs to come up with a way to sample individuals in the target group. Ideally, each member of the target group should have an equal chance of being in the sample (a sample of this sort is called a "random" sample). However, a "convenience" sample is likely to be easier (just ask anyone in the target group who is readily

accessible — but note that a convenience sample may not be representative of the target group).

d. Administer the questionnaire (Day 2). Assign each student to survey enough members of the target group to ensure a sample size of at least 50. Stress that it is important for everyone to use the survey exactly as it is written so that people's responses are not influenced by variations in the way students ask the questions.

e. Compile and analyze the results (Day 3).
Ask the class to determine the average value given
...overall
...by males
...by females
...by those in each of the income levels
...by those who have little familiarity with the benefits
...by those with good familiarity with the benefits
...by any other background characteristic that may be relevant
Assign the class to use this information to draw general conclusions about the effect of each characteristic on the value given.
Determine the total value of the product in question by taking the average value and multiplying it by the number of people in the target group. This yields an estimate of the total value of this product to the target group.

f. Write up a final report summarizing the study (Day 4). Divide the class into five groups and assign each of them the task of describing and summarizing one of the steps above.

EXTENSION ACTIVITIES

Science

10. Individually or in groups, students might investigate a particular type of pollutant and write a short report describing its possible physical effects (if any) on human health, animal populations, plant growth, aesthetics, climate, building materials, etc. Some obvious candidates include carbon monoxide, carbon dioxide, nitrogen oxides, particulates, hydrocarbons, lead, and mercury.

Statistics

11. Assign students to prepare bar graphs, pie charts, and histograms to display the data of the contingent valuation survey.

ACTIVITY 1

THE EFFECT OF HIGHER SULFUR DIOXIDE CONCENTRATIONS

A region is considering improving its air quality by reducing the average concentration of sulfur dioxide. Information on four principal effects of sulfur dioxide is summarized below. Based on this information, suggest ways to estimate how much people in this region would be willing and able to pay for reductions in the concentration of sulfur dioxide.

a. *Agricultural Productivity*
Local agricultural researchers have found that when all other inputs are the same (amount of water, fertilizer, tillage, etc.), soybean production per acre rises as the sulfur dioxide concentration falls.

b. *Maintenance*
Because of the corrosive effect of sulfur dioxide on metals and the discoloration it causes to stone, concrete, and painted structures, people and businesses in the region must wash, paint, and sandblast their structures more often.

c. *Aesthetics*
This region has a cold, moist climate. As the sulfur dioxide level rises and combines with atmospheric moisture, a grayish haze is formed which hangs over the area. This not only reduces visibility but turns what could be a beautiful blue sky into a gloomy gray one. Owning a home in the area generally becomes less desirable.

d. *Health*
Acute exposure to sulfur dioxide has been linked to a greater incidence of colds, coughs, and aggravation of asthma. Long-term exposure has been linked to a greater risk of emphysema and bronchitis. These effects show up in increased sick days and medical expenses (medicines and visits to the doctor).

Notes: Possible ways to estimate how much people would pay to reduce sulfur dioxide concentrations.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

MEASURING THE ANNUAL VALUE OF REDUCING SULFUR DIOXIDE LEVELS

Part 1: Measurement Possibilities

a. *Agricultural Productivity*
Assuming that local soybean farmers sell in a national market (so that their production levels have little influence on the price they receive), their income would rise by the market price times the increased amount of production. This rise in income represents the maximum amount they would be willing and able to pay for the improvement. Suppose the market price is $40 per ton and yearly production levels are estimated to vary as follows: currently, 100,000 tons; with a 5% reduction, 110,000 tons; and with a 10% reduction, 115,000 tons.

b. *Maintenance*
The maintenance expenses people would save from lower sulfur dioxide levels provide an estimate as to how much these people are willing and able to pay for an improvement. A survey of maintenance expenditures in the region has provided the following information: at current levels, $3.5 million is spent on maintenance; with a 5% reduction, only $2.5 million would need to be spent; and with a 10% reduction, only $2.0 million would need to be spent.

c. *Aesthetics*
Studies have been done to compare the market value of homes that are similar in all characteristics (number of rooms, size, age, location with respect to shopping and schools, etc.) except the average level of sulfur dioxide to which they are exposed. As one might expect, as the sulfur dioxide level falls, the selling price (and annual rental value) of the home tends to rise. In other words, people are willing and able to pay more for a home in an area with better air quality. In particular, a 5% reduction in sulfur dioxide concentration leads to an estimated 0.50% increase in home values, while a 10% reduction leads to a 0.90% increase. Currently, the annual rental value of all homes in the area is around $500 million.

d. *Health*
If levels of sulfur dioxide are reduced, people will not have to spend as much money on medical care or lose as many work days (lost income/productivity). Suppose that an estimated 10,000 working days per year are lost because of sulfur-dioxide-related illnesses, and that each day lost represents an average income loss of $200. In addition, suppose medical expenses related to these illnesses total $500,000. With a 5% reduction, only about 5000 working days would be lost, and medical expenses would fall to around $300,000. With a 10% reduction, 3000 working days would be lost and medical expenses would fall to $200,000.

(Activity 2 continued on p.122)

Part 2: Based on the information in Part 1, complete the following:

a. Estimate the value of increased agricultural productivity
...for the first 5% reduction: _____
...for the next 5% reduction: _____
...for a 10% reduction: _____

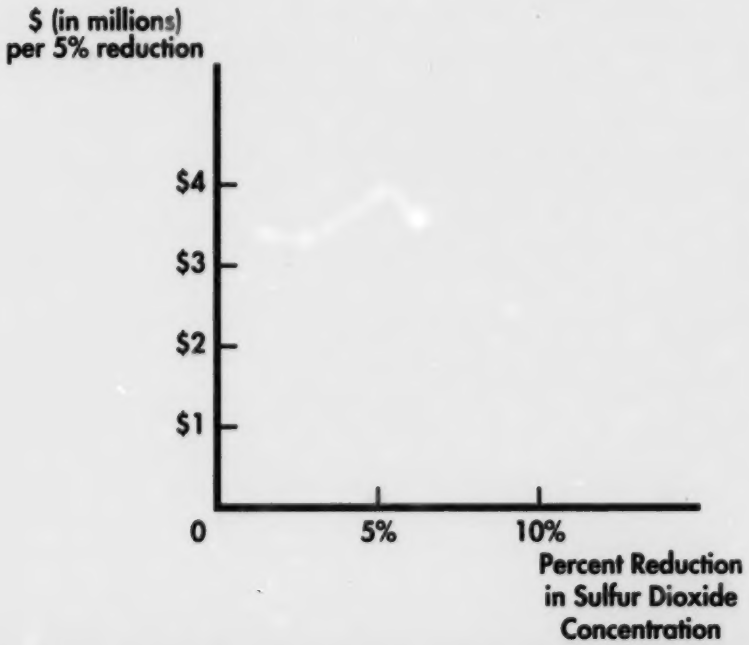
b. Estimate the value of reduced materials damage
...for the first 5% reduction: _____
...for the next 5% reduction: _____
...for a 10% reduction:_____

c. Estimate the value of improved aesthetics
...for the first 5% reduction: _____
...for the next 5% reduction: _____
...for a 10% reduction:_____

d. Estimate the value of improved health
...for the first 5% reduction: _____
...for the next 5% reduction: _____
...for a 10% reduction:_____

e. Estimate the total value (based on the above effects alone)
...for the first 5% reduction: _____
...for the next 5% reduction: _____
...for a 10% reduction:_____

f. On the graph below, plot the values you found in (e) for the first and second 5% reductions.



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

CONTINGENT VALUATION: SAMPLE QUESTIONNAIRE

Hello, my name is_____. My class at _____ school is conducting a study concerning a proposal to plant trees along Main Street.

Would you be willing to answer a few questions related to this proposal? (If yes, continue. If no, say "Thank you.")

The proposal is to plant trees along Main Street from South 10th St. to North 8th St. Four ten-foot maple trees would be planted on each side of each block for a total of 152 trees. Once planted, they would entail virtually no maintenance costs. The benefits of this proposal include increased beauty in the downtown area, shade in the summer, and a reduction in the potential effects of global warming.

1. How familiar are you with these potential benefits?
   _____ not at all or only a little
   _____ somewhat to very familiar

2. What is the maximum one-time amount you personally would be willing and able to pay to see that this proposal is carried out? $_____

If you don't mind, I would also like some background information on you and your family.

3. Sex: _____ Male _____ Female

4. Yearly Family Income (before taxes):
   ____< $20,000 ____$20,000 - $50,000 ____> $50,000

5. Number of People in your Family: _____

6. Highest Level of Education of Either Parent:
   ____ some high school
   ____ high school graduate
   ____ some college
   ____ college graduate
   ____ post-graduate

Thank you for participating in our study!

IS LIFE TRULY PRICELESS?

INTRODUCTION

How much should society spend to keep toxic wastes from killing people? Would you drink a glass of water containing dioxin if there was a one-in-a-million chance of dying from it? How much better would you feel if the chance was only one in a billion? Is *any* level of risk "acceptable"? Should society protect people from pollution "at any cost"? The answers to these questions depend upon how society values human lives. In this lesson students discover the sometimes surprising result that society in general does not place an infinite value on a life (whether it should do so or not).

ECONOMIC CONCEPTS

Value

ENVIRONMENTAL CONCEPTS

Statistical Life
Dioxin
Probability of Death

OBJECTIVES

- Explain the difference between a specific person's life and a statistical life.
- Describe "a reduction in the probability of death" as a product which has value and requires resources to produce.
- Calculate the value of a statistical life based on observation of the choices society makes.

LESSON DESCRIPTION

The lesson introduces various ways to place a value on a human life. The economic approach involves thinking of "a reduction in the probability of death" (or "an increase in life-saving measures") as a product, like other products, which has value and requires resources to produce. The quantity of resources to be devoted to producing this product may be decided by weighing the value of the product against the costs of producing it — as we do in the case of other products. Based on such an assessment, students calculate the value of a statistical life and examine values actually used by government agencies.

TIME REQUIRED

One class period

MATERIALS

Newspaper/magazine article describing a recent rescue effort
One copy for each student of Activities 1, 2, 3, and 4
Transparencies of Activities 1 and 4

PROCEDURE

What is a Human Life Worth?

1. Ask: What is a human life worth?
   Discuss responses as follows:
   Accept all answers. Answers will vary, and some students will say it is not possible (or even ethical) to place a value on a human life — that is, human life is "priceless" or of infinite value.
2. Then ask: How could people in our society measure the value of a human life? Show a transparency of Activity 1, or distribute copies of it. This activity lists some common approaches to the task of measuring the value of a life. Ask students to discuss, briefly, the merits of these alternatives and to suggest other possibilities. Tell the class that economists actually do not use any of these methods to determine the value of a life to a society. This leaves the

original question unanswered and also raises a new one: Why isn't life "priceless"?

Saving a Specific Person's Life

3. Present a newspaper or magazine article (which you have found and brought to class) describing some rescue effort (for example: finding miners after a cave-in, flying a donor organ across country, digging through building rubble for possible earthquake survivors, tunneling down to save a toddler who has fallen into an abandoned well, etc.). Ask students to describe the amount of resources (human, capital, natural) used in these efforts.

   Since these resources were diverted from other uses, they represent the cost of the rescue effort.

   Ask the class: Is the benefit of saving these lives worth the cost? Discuss responses:

   Most students will respond that it is (i.e., the goods and services that must be forgone when resources are diverted are less valuable than saving a specific person's life). In other words, the life of a specific person in certain danger has very large if not infinite value. In this case, a life is likely to be "priceless" to society.

4. Continue the discussion: What if these resources could save even more lives if they were used in another way? Economics tells us that resources are scarce. For example, suppose a single emergency crew (the resource) could respond to a car accident or to a burning building, but not both. Suppose lives are at stake in both cases. Ask: To which scene should the emergency crew go? Discuss responses:

   Answers will vary. It is important to emphasize that scarcity forces a choice; sometimes lives, even if they have an infinite value, may have to be given up.

Probability of Death

5. Now ask the class to consider how a life is valued when it isn't known for certain whose life may be in danger. For example, many pollutants in our air and water pose a health risk of some kind. Some people will inevitably be adversely affected, and some will die. But we don't know who or when. Distribute a copy of Activity 2 to each student. Explain its contents as necessary.

   At one end of the scale, the probability of death is 1.00 (that is, death is certain to happen), while at the other end the probability is zero (death is impossible). Note that the "probability of death" may be defined as the number of people who are expected to die as a result of engaging in some activity divided by the total number of people who engage in that activity.

6. Ask students working in groups of three to four to discuss where each of the activities listed might lie along the spectrum. Allow 10 minutes and then discuss their decisions in class. After a brief discussion, compare the students' rankings with the following estimates. (Most of the estimates are adapted from *What Are The Chances?*, by Bernard Siskin, Jerome Staller, and David Rorvik (Crown Publishers, Inc. 1989). Some estimates have not been calculated.)

   a. flying in a commercial airplane: .0000003 (0.3 chances in a million)
   b. driving/riding in a car: .0002 (200 chances in a million)

c. getting struck by lightning: .000001 (1 chance in a million)
d. smoking cigarettes: .00625 (6250 chances in a million)
e. working as a lumberjack: .001 (1000 chances in a million)
f. working as a police officer: .0004 (400 chances in a million)
g. playing "Russian roulette" with a six-shooter: .167 (166,667 chances in a million)
h. living in Southern California during the next 50 years: .0005 (500 chances in a million, reflects the probability of dying as a result of an earthquake measuring at least 8 on the Richter scale)
i. getting AIDS from a blood transfusion: .00001 (10 chances in a million)
j. staying at a motel: .0000004 (0.4 chances in a million, reflects the probability of dying in a motel fire)
k. having a baby: .00005 (50 chances in a million)
l. taking a prescription drug: .0005 (500 chances in a million, reflects the probability of dying from an adverse reaction)
m. living in a home with radon: .000005 (5 chances in a million)
n. falling down: .000002 (2 chances in a million)
o. dying from a heart attack: .60 (600,000 chances in a million; this is not the probability of having a heart attack, but the probability of dying if you do have a heart attack)
p. drinking water directly from a nearby river: ?
q. breathing air in your area: ?
r. eating vegetables sprayed with some herbicide or pesticide: ?
s. living near a nuclear power plant: ?

Comparing some of these values should lead to a lively discussion. (It might be noted that the perceived risk people associate with different activities often differs greatly from the actual level of risk.)
Note that items p-s relate to risk associated with the way we use the environment. Ask the students: How low should these risks be? Discuss responses.

7. Distribute a copy of Activity 3 and ask the students to complete it, again working in groups of three to four. Allow 10 minutes and then discuss their responses as follows:
   a. No. Neither of these activities has a zero probability of death. There is a risk of being involved in an accident (a drunk driver could weave into your lane unexpectedly) and a risk of lung disease from inhaling air pollutants. In fact, no activity is entirely risk-free. You could always be struck by a falling meteorite!
   b. If you value your life at all, yes. People express this value (willingness and ability to pay for risk reduction) by paying more for cars with better safety features and buying other products such as smoke detectors and air and water filters. These actions imply that reducing the probability of death is a valuable product.
   c. For highway driving: better road construction methods (wider lanes, fewer blind curves, more guardrails), better driver education, cars with additional safety equipment, and driving at slower speeds. For air pollution: less production of products (to reduce the amount of air pollution caused in the first place), increased

use of pollution control devices, restricted use of cars and trucks, and emissions released at timed intervals so the environment doesn't have to assimilate so much at one time.

d. For highway driving: most of these require that resources be diverted from other uses (so the value of these other uses is given up); for driving at slower speeds the costs are the value of time spent in other activities that must be given up and the increased cost of transporting resources and products. For air pollution: lost value of products, resources required for pollution control, lost convenience (see other costs in Lesson 4).

e. Students should remember that this goal is probably not even possible. For highway driving one could imagine designing cars resembling tanks, enforcing 2 mph speed limits, building "clover-leafs" at all intersections so roads do not cross each other, and building domed highways to prevent bad weather conditions — all in an effort to reduce highway fatalities to zero. But, would it be worth the cost? Similarly for air pollution one could imagine ceasing all use of energy and other natural resources, or collecting 100% of all wastes and sending them into outer space. Again, would it be worth the cost?

f. It depends on the value of additional reductions in the probability of death in each activity, and the cost of producing these reductions. If the value is high and the costs low, the probability of death should be reduced quite a bit. If the cost is high and the value low, it shouldn't be reduced as much. Thus, the "acceptable level of risk" (the probability of death) in different activities (such as driving and breathing air pollutants) may be different (such as one in a million versus one in a billion).

The Value of a Statistical Life

8. **If we know how much people value a reduction in the probability of death associated with a given activity, we can use that value to determine the value of a statistical life. Pose the following problem for students, working again in groups of three or four:**

There are one million people who fish in a given region. Suppose each of them is willing and able to pay $5 for a new water treatment process which will reduce the probability of death caused by eating fish taken from the region's waterways from .00011 (11 in 100,000) to .00010 (10 in 100,000). What does this suggest about how much a life saved by this process is worth?

This analysis may be difficult for some students, but it underscores the link between the probability of death and the implied value of a statistical life. To solve the problem, students first should determine how many lives will be saved; then they should divide that number by the total amount everyone is willing and able to pay for this change. For example: without the process, 110 lives would be lost (.00011 x 1 million), while with the process only 100 would be lost (.00010 x 1 million). Thus, the new process is expected

to save 10 lives. Since each person is willing and able to pay $5 for this reduction, the total value is $5 million ($5 x 1 million). So, 10 lives saved are worth $5 million, or each life is worth $500,000. Note that these are statistical lives — it is not known for certain which 10 of the 1 million users will have their lives saved.

9. **The implied value of a statistical life can also be determined by considering the costs of reducing the probability of death. Ask students to consider the following problem: Suppose the government begins requiring all incinerators to install a particular pollution-control device. The total cost of compliance is estimated to be $500 million. It is expected to reduce the probability of death from air pollution across the country (population 250 million) from .000002 (2 in 100,000) to .000001 (1 in 100,000). What is the implied value of a life if society decides this policy is worthwhile?**

   The number of lives lost drops from 500 (.000002 x 250 million) to 250 (.000001 x 250 million). So, 250 lives are saved at a cost of $500 million. Thus, each life must be worth at least $2 million ($500 million/250).

10. **Show a transparency of Activity 4. This activity shows the implied value of a statistical life based on decisions such as the one above, made by various government agencies. Note that the value of a statistical life varies from around $1 million to as high as $8 million, depending on the nature of the activity involved.**

EXTENSION ACTIVITIES

Government/Law

11. **When someone loses his or her life because of someone else's negligence, those affected can sue to recover damages imposed on them (such as loss of income, pain and suffering, medical/funeral expenses, etc.). Invite a forensic economist or an attorney who specializes in this area speak to the class about how the amount of damages is determined. Ask the class: Does this amount reflect the true value of the person's life? Discuss responses.**

    Most students will respond that no amount of money could replace the life of a loved one (i.e., the life of a loved one is infinitely valued), and so this amount is too low. Note that this is a case which involves attempting to place a value on a specific person's life. This is based on the "productivity value" listed in Activity 1.

Science

12. **Assign students to research the elemental make-up (percent of each element) of the human body. They should use these percentages to determine the weight of each element in their own bodies (students should use their own weights). Finally, they should determine the total value of these elements as described in (a) in Activity 1. Ask: What does this measure of value say about dieting?**

    Dieting will make you less valuable! This helps students see the absurdity of this measure.

13. **With reference to (b) in Activity 1, assign students to research exactly what body parts can currently be "reused" (for example, parts of the**

eye, lungs, livers, kidneys, hearts, bone marrow, others?).

Economics

14. Add the following to the discussion above: To estimate people's willingness and ability to pay for a reduction in the probability of death, economists consider the wage differences between similar jobs with different levels of risk. For example, if two similar jobs had probabilities of death of .00011 and .00010 respectively, one would expect the first to pay workers a slightly higher wage to cover the additional risk. If this difference was $5 per year, then it could be concluded that the reduction in probability of death is worth $5.

ACTIVITY 1

WHAT IS A HUMAN LIFE WORTH? SOME ALTERNATIVE "ECONOMIC" MEASURES

a. VALUE OF THE ELEMENTS
Break down a human body into its elemental parts: oxygen, hydrogen, carbon, magnesium, iron, zinc, and others. Determine the weight of each for an average person. Multiply the weight of each by the current market price of the element. Sum these values to get the total worth.

b. VALUE OF THE WHOLE IS THE SUM OF ITS PARTS
Many parts of the body are "in demand" by others as transplants (blood, heart, lungs, kidneys, liver, etc.). People's willingness and ability to pay for these individual parts could be summed to get the total worth.

c. A HUMAN LIFE IS "PRICELESS"
No monetary value can possibly be placed on a human life. It has an infinite value.

d. PRODUCTIVITY VALUE
A life is valued according to the production society would lose from having one less human resource. This loss can be measured by the present value of one's expected stream of future earnings.

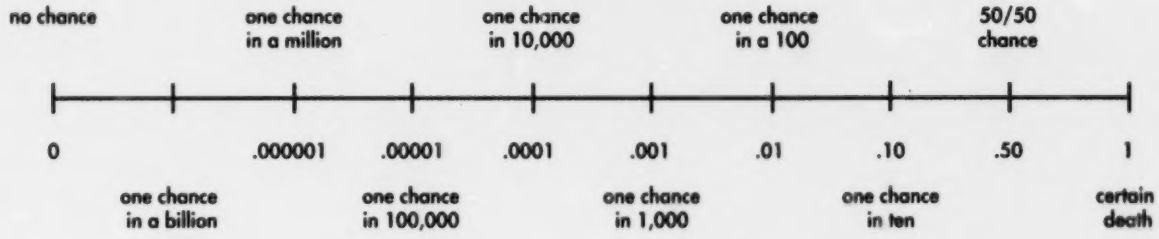
e. WILLINGNESS AND ABILITY TO PAY
Determine what people are willing and able to pay to avoid a certain death (note that this is not infinite, since people's "ability" to pay is limited).

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE PROBABILITY OF DYING FROM SELECTED ACTIVITIES

Probability of Death



The probability of death from engaging in a given activity may be defined as the number of people who are expected to die as a result of engaging in that activity divided by the total number of people who engage in it.

Discuss the probability of death from engaging in the following activities. Where would each activity lie along the line above? Which are most dangerous? Which are the safest?

a. flying in a commercial airplane
b. driving/riding in a car
c. getting struck by lightning
d. smoking cigarettes
e. working as a lumberjack
f. working as a police officer
g. playing "Russian roulette" with a six-shooter
h. living in Southern California during the next 50 years
i. getting AIDS from a blood transfusion
j. staying at a motel
k. having a baby
l. taking a prescription drug
m. living in a home with radon
n. falling down
o. having a heart attack
p. drinking water directly from a nearby river
q. breathing air in Los Angeles
r. eating vegetables sprayed with some herbicide or pesticide
s. living near a nuclear power plant

ACTIVITY 3

THE PRODUCT: A REDUCTION IN THE PROBABILITY OF DEATH

Consider two things you are likely to do in your lifetime: (1) drive on highways and (2) breathe polluted air in a large city. Answer the following questions for each of these activities:

a. Is either of these activities 100% safe (that is, the probability that you would die as a result of engaging in the activity is zero)?

b. Would you be better off if these activities were made safer (that is, if the probability of dying from engaging in them was reduced)?

c. Suggest some ways to make these activities safer.

d. What are the costs associated with these suggestions (that is, what exactly must be given up)?

e. Do you think society's goal for these activities should be to make them 100% safe?

f. If society's goal is to maximize the net value (benefits minus costs) it gets from each product, how much of the product (a reduction in the probability of death) should be produced in each of these cases?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

THE VALUE OF A STATISTICAL LIFE

Department of Agriculture: $1.1 million

Department of Transportation: $1.0 - $1.5 million

Consumer Product Safety Commission: $1.5 - $2.0 million

Occupational Safety and Health Administration: $2 - $3.5 million

Nuclear Regulatory Commission: $5 million

Environmental Protection Agency: $1.6 - $8 million

Source: Ted Miller, Urban Institute (1990).

UNIT 5

IMPLEMENTING ENVIRONMENTAL SOLUTIONS

NEGOTIATE OR TAKE THEM TO COURT?

INTRODUCTION

Some people argue that we don't need new environmental regulations and controls to deal with many of our environmental problems. As long as property rights are defined and enforced, they contend, it is possible through private negotiation or the court system to achieve the most valued use of natural resources. In this lesson students explore the possibilities and the limitations of negotiation and court rulings.

ECONOMIC CONCEPTS

Coase Proposition
Property Rights
Common Law
Allocative Efficiency

OBJECTIVES

- Describe how negotiations between people can solve environmental problems.
- Explain how negotiations between people yield "market-like" results.
- Describe the use of common law to solve environmental problems.
- Explain the limitations of these approaches.

LESSON DESCRIPTION

Students, acting in pairs, play the roles of a fishing resort owner and a chemical company president in attempting to negotiate an agreement about how a lake is to be used. Their solution is shown to be that which maximizes the value obtained from the lake. Students next consider how a court might decide this case. Finally, another case is introduced to demonstrate the potential limitations of resolving all environmental problems with these approaches.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-6
Day 2: Steps 7-10 plus any Extension Activities

MATERIALS

Activities 1 a-d (enough of each for one-fourth of the class)
One copy for each student of Activities 1, 2, and 3

PROCEDURE

Negotiating the Use of a Lake

1. Form pairs of students. For half the pairs, give Activity 1a to one student and Activity 1b to the other. For the other half, give Activity 1c to one student and Activity 1d to the other. Ask each student to read his or her particular situation and stress that each must act as if he or she were the person described, with the values given (in particular, students must set aside their own personal beliefs or values).

   Before the students begin their negotiations, suggest that they deal with emissions 100 pounds at a time. If they agree on a trade of some kind for this 100 pounds, they should note the amount and then move to the next 100 pounds, etc. The total negotiated settlement will then be the sum of all the agreed upon individual amounts. Allow 20 minutes for negotiating. Provide assistance as necessary.

   This activity may be difficult for some students. Move around the room and help students as necessary; make sure they understand the incentives to bargain that are .

Resort Owner Owns the Lake		Chemical Company Owns the Lake	
Pounds of Emissions to be going in the Lake	Total Negotiated Settlement (payments to Resort Owner)	Pounds of Emissions to be going in the Lake	Total Negotiated Settlement (payments to Company)
____	____	____	____
____	____	____	____
...	...	...	...

involved here. Suggest that they concentrate on what they have to gain or lose as a result of each 100 pounds of emissions.

2. **Direct each pair write down the negotiated amount of emissions that will be going into the lake, plus the settlement amount. After the pairs report these amounts to the class, write the amounts on the chalkboard in a table such as the one shown above.**

   Most pairs should arrive at 300 pounds being emitted into the lake and 500 being controlled. For the first pair of students (where the resort owner owns the lake), the settlement amount should be somewhere between $4500 (the minimum the resort owner would be willing and able to accept to allow 300 pounds of emissions — $1000 + $1500 + $2000) and $19,000 (the maximum the chemical company would be willing and able to pay to avoid having to clean up its last 300 pounds of emissions — $12,000 + $4500 + $2500), depending on who was the better negotiator. For the second pair of students (where the chemical company owns the lake), the settlement amount should be somewhere between $5000 (the minimum the chemical company would be willing and able to accept to control 500 pounds of emissions — $200 + $300 + $1000 + $1500 + $2000) and $45,500 (the maximum the resort owner would be willing and able to pay to have 500 pounds of emissions controlled — $25,000 + $10,000 + $5000 + $3000 + $2500), again depending on who was the better negotiator.

3. **Ask some pairs who did reach this conclusion, and some who did not, to explain their reasoning. Discuss responses.**

   The most common reason for not achieving these results is that the students will add some of their own personal assumptions or beliefs to the problem ("I would never let anyone pollute my lake!"). This amounts to ignoring the "values" listed and substituting different ones. It is important to note that had the people in this case had different values the result of the negotiations would have been different.

4. **Distribute a copy of Activity 2 to each pair of students. Direct them to complete the worksheet, using the information provided on Activity 1. Allow 10 minutes and then discuss the answers as follows:**

   a. Completed table (see next page):

Emissions Into the Lake (pounds)	Emissions Controlled (pounds)	Benefits to Resort (Revenues Saved)	Benefits to Company (Control Costs Saved)	Total Benefits
0	800	$50,000	$0	$50,000
100	700	49,000	12,000	61,000
200	600	47,500	16,500	64,000
300*	500	45,500	19,000	64,500*
400	400	43,000	21,000	64,000
500	300	40,000	22,500	62,500
600	200	35,000	23,500	58,500
700	100	25,000	23,800	48,800
800	0	0	24,000	24,000

b. As an aesthetically-pleasing fishing site and as a depository for production wastes.
c. $50,000 (0 pounds of emissions into the lake).
d. $24,000 (800 pounds of emissions into the lake).
e. 300 pounds of emissions into the lake (some use as a waste depository, still fairly good for fishing), total benefits: $64,500.
f. Should be the same — that is, private negotiations between the parties involved should lead to the highest valued use of a resource (in this case, the lake).

5. Show a transparency of Activity 3. These figures depict the "markets" for emissions allowed into the lake (where the resort owner is the supplier and the chemical company is the demander — as in Activity 1a and 1b) and emissions controlled (where the resort owner is the demander and the chemical company is the supplier — as in Activity 1c and 1d). The demand curve in each case depicts the additional benefits the demander would receive from more of the product. The supply curve depicts the additional costs the supplier must incur to produce the product. As long as the additional benefits received are greater than the additional costs, there is room for negotiating which benefits both participants. Note that this is true up to 300 pounds of allowable emissions into the lake in the first case and up to 500 pounds of emissions controlled in the second case. Since these "markets" are mirror-images of each other, the same basic result is obtained in both: 300 pounds are emitted into the lake and 500 pounds are controlled. Also note that the net value of each product (emissions allowed into the lake and emissions controlled) is maximized.
6. Closure: This exercise demonstrates the Coase (pronounced "kos") Proposition (named after Ronald Coase, who first formulated the idea in "The Problem of Social Cost" in *The Journal of Law and Economics*, October 1960). This proposition says that as long as the property rights to a resource are assigned to someone (and it really doesn't matter who!), the use of the resource which maximizes the value generated from it can and will result if the parties involved are free to negotiate among themselves. It suggests that some environmental problems could be solved by simply having the government assign and enforce property rights better.

Take Them to Court!

7. Pose to students the following: Suppose the ownership of the lake is unassigned and the company builds its production plant and starts emitting wastes into the lake. What recourse would the resort owner have? Discuss responses.

   Most students will suggest that the resort owner could take the company to court and sue for damages (lost revenues) incurred and/or ask that the company stop any future emissions.

8. Court action of this sort is based on liability laws encoded in what is called the common law. The "golden rule" of common law is that you can do anything you want to with your private property, as long as what you do does not interfere with your neighbors' ability to enjoy their private property. If it does interfere, you can be held liable for any damages caused. Given this, ask the students: How might common law be used by the company in its defense? Discuss responses.

   The company could argue that the resort's demand for a waste-free lake imposes damages on it in the form of unnecessary control costs.

9. Ask: What would you expect a judge in such a case to do, assuming there were no regulations concerning the emission of wastes? Discuss responses.

   The judge probably would try to "balance the damages." In other words, she would weigh the damages or benefits of each and find a compromise.

   Note: to the extent that this occurs, the same result found earlier through negotiation might also be obtained through court action.

The Limitations of Negotiating and Litigation

10. To demonstrate the limitations of deciding on contested cases of resource use through negotiation or litigation, divide the class in half. The first half will represent people who enjoy fishing on a particular stretch of Scenic River. The second half will represent companies, farmers, and even wild animals who use Scenic River to dispose of some of their wastes (organic and inorganic wastes, agricultural run-off, metals, salts, fecal material, etc.). Ask students to suggest reasons why it would be difficult to negotiate or litigate a solution which maximizes the value received from Scenic River. Possible responses follow:

    a. Too many people are involved. It would difficult even to get everyone together.
    b. The costs of bargaining and/or the costs of lawsuits would be expensive, in both time and money. The costs may be so high that people will decide to put up with the situation as the lesser of two evils.
    c. Judges can be arbitrary in their decisions or may use criteria other than "maximizing the value generated from the use of the river."
    d. It may be difficult to determine who is actually responsible for a particular quantity of damage being suffered. Those being sued will likely try to pass the blame onto others.
    e. It may be difficult to place a monetary value on the damages. In the case of the resort owner and chemical company above, it is important to note that the

numbers used were estimates by the resort owner and the chemical company; how accurately these reflect the actual values depends upon how carefully each source researched and valued each option.

The basic point is that when large numbers of people are involved, when it is difficult to determine who exactly is responsible for any damages caused, or when assessing the value of damages is difficult, negotiation and court solutions become very cumbersome and will probably not result in efficient solutions.

EXTENSION ACTIVITIES

Science

11. Divide the class into five groups and ask each group to research and report on the link between one of the emission types below and its environmental impact (in particular, on fish populations).
    - *Organic nutrients* (emissions from paper mills, feedlots, sewage treatment facilities, etc.)

      Bacteria in water use dissolved oxygen when consuming these wastes, causing low oxygen levels and fish deaths. It should be noted that all fish species are not affected in the same way. While some species such as carp can survive in low-oxygen conditions, others such as smallmouth bass cannot. If oxygen levels get too low, anaerobic bacteria take over, producing aesthetically bad-smelling methane and hydrogen sulfide gases.
    - *Inorganic plant nutrients* (such as nitrogen, phosphorus, potassium, sulfur, etc.)

      These emissions lead to excessive growth of algae and plants which can impair fishing, swimming, and boating. When the algae and plants die and are degraded by bacteria, then, as noted above, the result may be low oxygen levels and fish deaths.
    - *Toxic organics* (synthetic organic compounds)

      While the largest concern is human cancers, these emissions can also lead to fish deaths.
    - *Toxic inorganics* (metals, acids, salts, etc.)

      Similar to c, above. It should be noted that all fish species are not affected in the same way. While some species such as carp can survive in very acidic conditions, others like the smallmouth bass cannot.
    - *Thermal effects* (changes in the water temperature)

      If the change is sudden it can kill many fish outright. Since higher water temperatures lower the amount of dissolved oxygen, some species could be eliminated by very small temperature changes (+10 degrees C). Naturally, much higher levels can kill most species.

Government/Law

12. Assign students to research a particular court case involving environmental damages (for example, litigation arising from the oil spill of the Exxon Valdez or a local case of groundwater or soil contamination). They should determine what property rights were involved or violated, how liability was determined, and how damages were determined.

ACTIVITY 1a

FISHING FOR A SOLUTION

You own a fishing resort alongside a small lake (which you also own) that is widely known for its natural beauty and great sportfishing (including fishing for smallmouth bass). Your business depends heavily on the quality of this lake. Some of the land adjoining the lake is owned by a company which specializes in the production of chemicals used in the recycling of various paper products. Because of expanding recycling markets, the company has begun construction of a production facility on its land. While the facility itself should not pose any particular aesthetic problems for your resort (it is being built well back of the lake shore), you are concerned that it might try to use the lake as a depository for some of its wastes (projected to be 800 pounds per day). As the amount of emissions increases, the impact on the aesthetic quality of the lake also would increase, as would the potential for loss of some fish populations. These losses would directly affect your revenues. You have estimated the following effects on the lake and your revenues:

Emissions Into the Lake (per day)	Effect on the Lake	Lost Revenues* (per year)
1st 100 pounds	Slight change in water color	$1000
2nd 100 pounds	Slight change in smell	1500
3rd 100 pounds	More noticeable color change	2000
4th 100 pounds	Lake appears less clear	2500
5th 100 pounds	Noticeable smell/vegetation loss	3000
6th 100 pounds	Small decrease in bass population	5000
7th 100 pounds	Noticeable decrease in bass stock	10,000
8th 100 pounds	Bass killed/also loss of other fish	25,000

(*To find the total amount of revenues lost, sum these. For example, the total revenues lost if 400 pounds of wastes are emitted into lake would be the loss from the first 100 pounds ($1000), the 2nd ($1500), the 3rd ($2000), and the 4th ($2500), or $7000.)

Since you have the legal right to prohibit any unauthorized use of your lake, your concern is limited. However, the president and CEO of the company wishes to talk to you about possibly allowing some emissions into the lake. You have agreed to meet. After all, if the company is willing and able to pay you at least $1000 to cover your estimated revenue losses, you would certainly consider allowing it to emit 100 pounds per day. Maybe the company will offer even more! Try to negotiate the best deal you can (keep the above information confidential!).

ACTIVITY 1b

FISHING FOR A SOLUTION

You are the president and CEO of a company that specializes in the production of chemicals used in the recycling of various paper products. In recent years the demand for products using recycled materials has grown dramatically. In turn, so has the demand for your products. Your current plant can no longer keep up with the increased orders. Thus, you have decided to construct a new production facility on land the company already owns adjoining a small lake. You would like to use the lake as a depository for some of the wastes generated in your production process (projected to total 800 pounds per day), but the lake is owned by a fishing resort located across the lake from you. If you were allowed to emit some of these wastes into the lake it would save you the cost of controlling them. These savings have been estimated by your engineers as shown below:

Emissions Allowed Into the Lake (per day)	Savings in Control Costs* (per year)
1st 100 pounds	$12,000
2nd 100 pounds	4500
3rd 100 pounds	2500
4th 100 pounds	2000
5th 100 pounds	1500
6th 100 pounds	1000
7th 100 pounds	300
8th 100 pounds	200

(*To find the total control costs saved, sum these. For example, the total control cost savings if 400 pounds of emissions were allowed into the lake would be the savings from the 1st 100 pounds ($12,000), the 2nd ($4500), the 3rd ($2500), and the 4th ($2000), or $21,000.)

As indicated by those values near the bottom of the table, the first few pounds of wastes can be controlled fairly cheaply (mostly by installing some simple control devices). Control beyond that requires more expensive equipment and ultimately major and very costly changes in the production process itself.

Assuming the resort is fully within its legal rights to control the use of the lake as it wishes, you decide to approach the resort owner in hopes of negotiating some emissions allowances. Note that the company could save $12,000 in control costs if you could get the resort to allow you to emit just 100 pounds per day. Negotiate with the resort owner and try to make the best deal you can (keep the above information confidential!).

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 1c

FISHING FOR A SOLUTION

You own a fishing resort alongside a small lake that is widely known for its natural beauty and great sportfishing (including fishing for smallmouth bass). Your business depends heavily on the quality of this lake. The lake (and some adjoining land) is owned by a company which specializes in the production of chemicals used in the recycling of various paper products. This company has allowed those who stay at your resort free access to fishing on the lake.

Because of expanding recycling markets, the company has begun construction of a new production facility on its land. While the facility itself should not pose any particular aesthetic problems for your resort (it is being built well back of the lake shore), the projected emission of wastes into the lake (800 pounds per day!) has you very concerned. As the amount of emissions increases, so will the impact on the aesthetic quality of the lake and the potential loss of some fish populations. These losses would directly affect your business. You have estimated that you would lose $50,000 in revenues if the company emits all 800 pounds. If the emissions could be reduced, some of these losses could be avoided as shown below:

Pounds of Emissions Controlled (per day)	Benefit to the Lake	Revenues Saved* (per year)
1st 100 pounds	Avoids total bass kill	$25,000
2nd 100 pounds	Increases growth of bass stock	10,000
3rd 100 pounds	Bass population is fairly healthy	5000
4th 100 pounds	Reduces smell, increases vegetation	3000
5th 100 pounds	Lake becomes less cloudy	2500
6th 100 pounds	Natural color of the lake returns	2000
7th 100 pounds	Lake has only slight smell	1500
8th 100 pounds	Lake is restored to natural state	1000

(*To find the total revenues saved, sum these values. For example, the total revenues saved from having 400 pounds of emissions controlled would be the sum of the amount saved from the 1st 100 pounds ($25,000), the 2nd ($10,000), the 3rd ($5000), and the 4th ($3000) or, $43,000.)

Assuming the company is fully within its legal rights to use the lake as it wishes, you decide to approach the president of the company in hopes of negotiating a reduction in its emissions. Note that you estimate it will save you $25,000 in lost revenues if you can get the company to control just 100 pounds of emissions! If you could offer the company enough to control the next 100 pounds, you would save another $10,000. Try to obtain the best deal you can (keep the above information confidential!).

ACTIVITY 1d

FISHING FOR A SOLUTION

You are the president and CEO of a company that specializes in the production of chemicals used in the recycling of various paper products. In recent years the demand for products using recycled materials has grown dramatically. In turn, so has the demand for your products. Your current plant can no longer keep up with the increased orders. Thus, you have decided to construct a new production facility on land the company already owns adjoining a small lake (which the company also owns). Not only will the new plant help your company meet the extra demand, but the lake can also serve as a depository for the wastes generated in the production process (expected to total 800 pounds per day). This means of disposal will save the company a lot of waste control costs, as has been estimated by your engineers below:

Pounds of Emissions Controlled (per day)	Treatment/Control Costs* (per year)
1st 100 pounds	$200
2nd 100 pounds	300
3rd 100 pounds	1000
4th 100 pounds	1500
5th 100 pounds	2000
6th 100 pounds	2500
7th 100 pounds	4500
8th 100 pounds	12,000

(*To find the total control costs, sum these. For example, the total cost to control 400 pounds of emissions would be the sum of the 1st 100 pounds ($200), the 2nd ($300), the 3rd ($1000), and the 4th ($1500), or $3000.)

As indicated by the table, the first few pounds of residuals can be controlled fairly cheaply (mostly by installing some simple control devices). Control beyond that requires more expensive equipment and ultimately major and very costly changes in the production process itself.

On the other side of the lake is a fishing resort. In the past your company has freely allowed visitors at this resort to fish on the lake. The resort owner has contacted you expressing concern about the effects of your emissions on the lake and the resort's financial survival. You have agreed to meet the owner to discuss controlling your emissions. After all, if the owner is willing and able to pay at least $200 (the cost of controlling the first 100 pounds of emissions), you would certainly consider controlling them — you might even be able to make something on the deal! Try to negotiate the best deal you can (keep the above information confidential!).

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE BENEFITS (VALUE) GENERATED BY THE LAKE

a. Complete the table below, using the information from Activity 1 (some figures are already included to help guide your work).

Emissions Into the Lake (pounds)	Emissions Controlled (pounds)	Benefits to Resort (Revenues Saved)	Benefits to Company (Control Costs Saved)	Total Benefits
0	800	$50,000	$0	$50,000
100	700	49,000	12,000	61,000
200	600	_____	_____	_____
300	500	_____	_____	_____
400	400	43,000	_____	_____
500	300	_____	22,500	_____
600	200	_____	_____	_____
700	100	25,000	23,800	_____
800	0	0	_____	24,000

b. The lake has two valuable uses in this case study. What are they?

c. If the lake were used solely for fishing and no emissions were allowed in the lake, what would be the total benefits or value generated by the lake?

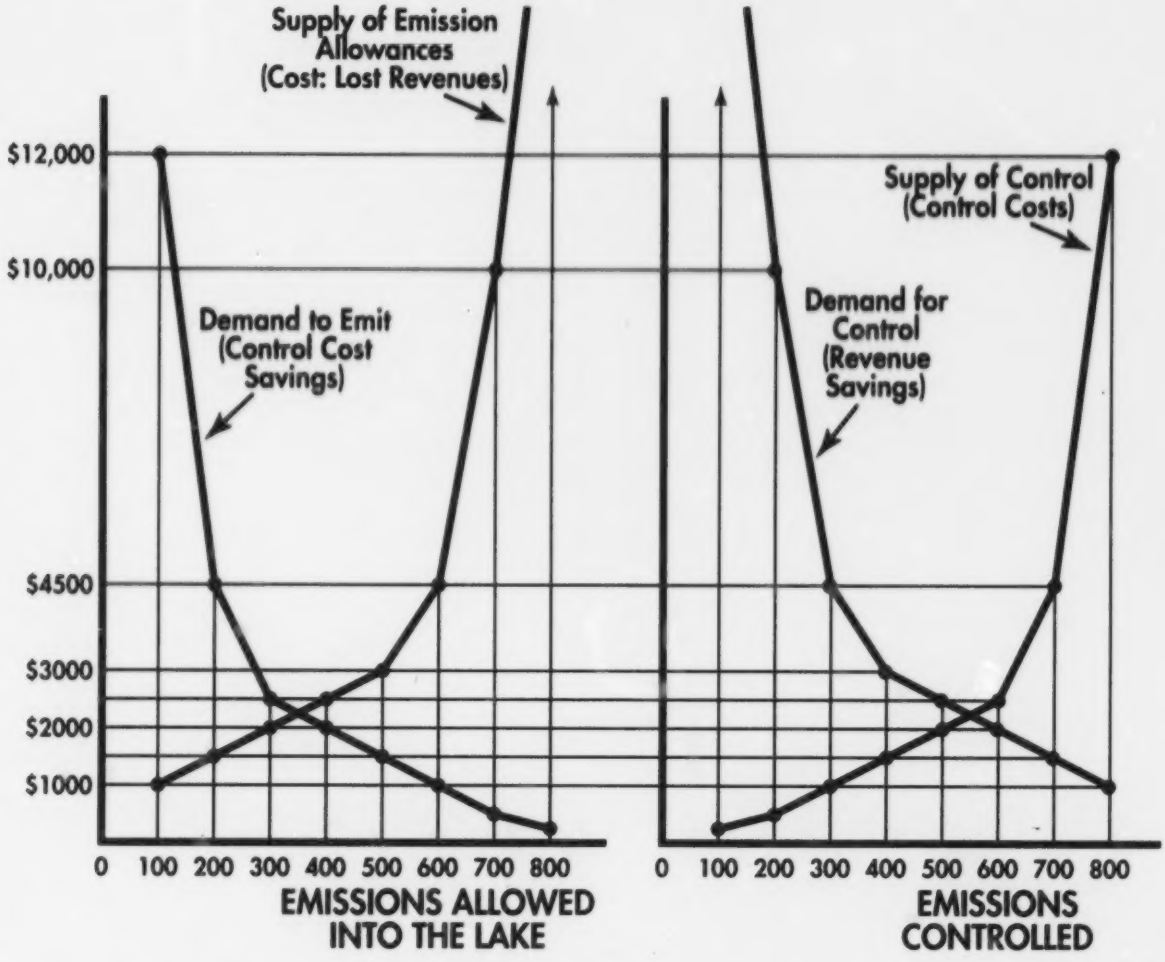
d. If the lake were used solely as a waste depository, what would be the total benefits or value generated by the lake?

e. What amount of each of these uses (measured in terms of the amount of emissions into the lake) maximizes the total benefits generated by the lake? What is the amount of the total benefits generated from the lake?

f. Compare this to your negotiated use of the lake.

ACTIVITY 3

THE NEW MARKETS



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

REGULATION: IS JUST SAYING "NO" ENOUGH?

INTRODUCTION

Much regulatory policy in the United States is based on prohibiting a particular behavior and then enforcing compliance through fines and other penalties. The idea is to tell people or businesses not to do something and then make sure they don't do it. This approach has been widely used in the area of pollution control. An important question this approach raises is whether or not making something against the law is enough — especially with respect to controlling pollution. In this lesson students learn how regulation is applied and consider the economic incentives associated with compliance.

ECONOMIC CONCEPTS

Economic Incentives
Benefits
Costs

ENVIRONMENTAL CONCEPTS

Ambient Standard
Emission Standard
Technology-based Standard

OBJECTIVES

- Describe the regulatory approach of setting standards.
- Compare pollution standards to other performance standards.
- Explain how an understanding of economic incentives may be used to improve compliance with a standard.

LESSON DESCRIPTION

By responding to teacher questions about the familiar case of speed limits, students are introduced to pollution standards. Then they compare speed limits and pollution standards, considering how the appropriate level is set, how uniformly it is applied, how it is enforced, and how well people and businesses obey it.

TIME REQUIRED

One class period

MATERIALS

One copy for each student of Activities 1, 2, 3, and 4 (plus Activities 5E and 6E)
A copy of an unusual local law or ordinance
Perfume spray (if the Science/Geography Extension Activity is desired)

PROCEDURE

It's Against the Law!

1. Ask students to describe some laws with which they are familiar. Discuss responses.

   Examples might include: traffic laws, drinking and smoking restrictions, building codes, anti-trust laws, laws against committing murder, assault, theft, etc. If you can find a peculiar or strange local ordinance or law — for example, a leash law for walking crocodiles or an ordinance which prohibits door-to-door solicitors from knocking more than two times — tell students about it to heighten their interest. A local attorney or city official is often a good source for these little quirks in the law.

2. Ask: What do these laws attempt to do?

   Control certain types of behavior that may be harmful to the general public.

3. Ask: What is the penalty for violating these laws?

Generally fines (monetary cost) and/or jail (time cost).
Note that many laws are in the form of standards which establish limits that one's behavior must stay within. Speed limits are perhaps the most obvious example.

4. **Ask students to identify some others.** Hunting and fishing limits, alcohol limits in the bloodstream when driving, park within 18 inches of the curb, water your lawn only on designated days, etc.
5. **Standards are also commonly used in environmental policy. These standards generally establish limits on how much of a potential pollutant people can emit into the environment. Distribute a copy of Activity 1 to each student and discuss the three types of environmental standards listed. Note that these standards essentially outlaw any emissions greater than the level set by the standards — an attempt to control the behavior of polluters.**

Setting the "Speed Limit" on Emissions

6. **The nature of emission standards can more easily be discussed by comparing them to a standard with which students are more familiar — speed limits. Distribute a copy of Activity 2 to each student and ask the students to work in groups of two to three to answer the questions. Allow 10 minutes and then discuss their answers in class, as follows.**
   a. 55 miles per hour.
   b. Presumably to reduce the number of accidents and save lives.
   c. This would involve many costs. People would have to spend more of their time traveling and so would have to give up some other activities. The cost of transporting products around the country would also be very high. Fewer products would likely be available in some areas, or available only at a much higher price.
   d. Note that because we have a speed limit higher than five miles per hour, society's goal apparently is not to minimize the number of lives lost but instead to maximize the net benefit (benefits minus costs) it receives from allowing faster travel. Zero or five miles per hour is not chosen since the costs (see c. above) of traveling very slowly must outweigh (at least to society as a whole) the benefits (the lives that would be saved). Similarly, the speed limit is not 100 miles per hour because presumably the benefits of permitting travel at that speed are not worth all the additional lives that would be lost.
   e. No. It is 65 on rural sections of interstate highways, 25-40 on city streets, and even lower in school zones and mall parking lots.
   f. Again, it is probably a matter of benefits and costs. The potential for losing lives varies with these different situations. On a limited-access, divided highway there is less risk of an accident (lower potential costs in terms of lives lost), and so faster speed limits have been allowed there. The greater density of cars and increased cross-traffic in a city increase the potential cost, and so lower speed limits are enforced there. In school zones there are children who may not

be safety-conscious, and so even lower limits are established in school zones. Likewise, heavy pedestrian traffic in and around mall parking lots increases the likelihood of an accident.

7. **Next distribute a copy of Activity 3 to each student. Tell the students to stay in their same groups and answer the questions asked, using Activities 1 and 2 as references. Allow 10 minutes and then discuss their answers in class, as follows.**
   a. They both set never-exceed levels: one, in miles per hour; the other, in pounds per day.
   b. Presumably to reduce the harmful effects of such emissions on the environment and people.
   c. The costs (see Lesson 4) of reducing, treating, or otherwise controlling all emissions could be prohibitively expensive.
   d. As in the case of speed limits, society's goal is more often to maximize net benefits — that is, to consider all the benefits and costs in determining where the standard should be set.
   e. No. The costs of controlling some pollutants may be fairly low, while the damages caused by the pollutants may be very great. In this case, net benefits would be maximized by fairly strict (closer to zero) emission standards. If, on the other hand, the costs rise significantly as a standard is made more strict, and if the potential damages the pollutant would cause to people and the environment are somewhat limited, net benefits would probably be maximized by a fairly relaxed (further from zero) standard.
   f. As suggested by speed limits, probably not. In those areas where the environment's ability to assimilate wastes is greater, where the environment is less sensitive, or where fewer people would be affected, greater amounts of emissions could be allowed. As a simple example of this, note that smoking may be banned (a zero emissions standard) inside a building where ventilation is limited and many people are exposed, but outside a building one can usually smoke freely (unlimited emissions are allowed).

Enforcing the Standards

8. **Continue exploring the parallel between speed limits and emission standards. Ask: How are speed limits enforced?**
   Police officers or the highway patrol monitor speed with radar guns. Violators are ticketed and must pay a fine.
   Note that emission standards are enforced in a similar manner. Officials from a local or state pollution control agency periodically check emissions or control equipment to find out whether emitters are in compliance with the standards. Violators are fined.
9. **Continue by asking: How well do people obey posted speed limits?**
   Most students know from their own observation that these limits are often violated.
10. **Ask students whether they can give an economic explanation for the fact that people often violate speed limits. In particular, suggest that they consider the benefits and costs of**

exceeding the speed limit. Record their responses on the board (one column for "Benefits" and another for "Costs").

Some possible benefits: (1) save time, which can then be spent on more enjoyable activities; (2) enjoy the feeling of going fast; (3) believe it makes one look cool.

Some possible costs: (1) the possible fine if caught; (2) a loss of self-respect from not doing the right thing; (3) higher probability of being injured or killed in an accident.

11. **Note that if an individual believes the benefits of exceeding the speed limit exceed the costs, he or she will likely choose to exceed it. Ask students to apply this same principle to a waste emitter who is considering violating an emission standard. What might the benefits and costs be in this case?**

    Main benefit: avoid paying control or treatment costs. Main costs: legal costs; possible fine; if the waste emitter is a business, a possible loss of customers who prefer to deal with "more reputable" firms. As discussed above, if the waste emitter decides the benefits exceed the costs, he or she may choose to violate the standard.

12. **Ask: What does this suggest about how regulators might ensure better compliance with standards (including both speed limits and emission standards)?**

    The benefits associated with violating the standard must be reduced, or the costs must be increased. The next step asks students to consider how the costs could be increased.

How Well Have Standards Worked?

13. **One of the principal costs of violating an emission standard is the possible fine or "expected penalty." The expected penalty equals the size of the penalty times the probability of it being imposed. Distribute a copy of Lesson 13, Activity 4 to each student (or show it as a transparency). This activity shows what must happen for a violator to actually receive a fine. It also provides some anecdotal information on the probability that the enforcement agency will be able to complete each step. Ask the class draw some conclusions from this. Discuss responses.**

    The probability of being fined is small; so is the likely penalty. This makes the "expected penalty" low and gives waste emitters an incentive to ignore the standards.

14. **Ask: How could compliance be increased?**

    By increasing the expected penalty — e.g., by increasing the probability of being caught through increased enforcement (better monitoring, more "pollution cops") and/or increasing the size of the fine. Note that the former step requires that additional resources be diverted into pollution control.

15. **Ask: Why might "perfect" compliance not be society's goal — in speed control or pollution control?**

    The enforcement costs needed to assure 100% compliance would be very high — a speed or pollution cop at every corner! The benefits of perfect compliance would probably not be worth the costs.

    Enforcement, like every other product, requires resources to produce. Allocative efficiency suggests that these costs should be weighed against the benefits received in deciding how much to produce (or enforce).

EXTENSION ACTIVITIES

Math

16. Explain that events are said to be "independent" if the occurrence of one gives no information about the probability of the other occurring. When events are independent, then the probability of several of them occurring is just the product of their individual probabilities (in symbols, given events A, B, and C, the probability of all of them occurring, P(A and B and C) equals P(A) x P(B) x P(C)).
17. Suppose the events in Activity 4 are independent (you might have students give reasons why this is or is not a good assumption). Assign students to complete Activity 5E. Discuss results as follows.
    a. (.50) x (.50) x (.50) x (.50) = .06 — less than 1 chance in 11.
    b. (.90) x (.70) x (.70) x (.70) = .31 — less than 1 chance in 3.
    c. (.80) x (.80) x (.40) x (.80) = .20 — about 1 chance in 5.
    d. $50,000: a. EP = (.06) x $50,000 = $ 3,000.
    b. EP = (.31) x $50,000 = $15,500.
    c. EP = (.20) x $50,000 = $10,000.
    e. $20,000: a. EP = (.06) x $20,000 = $ 1,200.
    b. EP = (.31) x $20,000 = $ 6,200.
    c. EP = (.20) x $20,000 = $ 4,000.
    f. Every case except b. with a penalty of $50,000. (Note: for both (f) and (g) below the polluter is assumed to be risk-neutral (neither risk-averse nor a risk lover.)
    g. Only case a. with a penalty of $50,000 or $20,000 and case c. with a penalty of $20,000.

Economics

18. This activity illustrates the incentives associated with a technology-based standard versus an emissions standard. Distribute a copy of Activity 6E to each student. After five minutes, discuss the answers in class, as follows.
    a. Method C, as it is the least costly of the four methods. Remind students that the goal of firms is to maximize their profits, so they will always try to minimize their costs.
    b. It has no choice. It would have to use Method A even though it has a less expensive way (Method C) to achieve a 50% reduction.
    c. With an emissions standard it would switch from Method C to this new method, since it is less costly. With the technology-based standard it would continue with Method A unless the regulatory agency changed the mandated technology.
19. Summarize the following two conclusions: (1) achieving emissions control with technology-based standards will typically be more expensive than with emissions standards since firms may have less costly options and (2) technology-based standards reduce the incentive for firms to develop or consider less costly pollution control methods. Given this, why should we ever consider using technology-based standards? What advantage do they have?

    They are much easier to enforce (just check to see that the technology is being used) and they provide better assurance that emission control is actually occurring (if the technology is

designed and known to reduce emissions by 50%, then, if it is being used, a 50% reduction should be guaranteed).

Science/Geography

20. The relationship between the amount of some pollutant emitted and the ambient concentration of that pollutant depends on how the emissions are dispersed or diffused into the environment. For a simple diffusion demonstration, position students at various places around the room; then spray some perfume into the air from some point. Ask students to raise their hands when they can first smell the perfume. Repeat the experiment with a fan turned on to show how the diffusion pattern is altered.
21. Assign students to follow this up by writing short reports on one of the following:
    a. The effect of winds, rain, and temperature (inversions) on dispersing air pollutants.
    b. The "oxygen-sag" which results from the depositing of organic wastes in rivers and the effect of the speed of the current on this.

In discussing the reports, make the point that ambient concentration is not determined simply by the quantity of emissions released. Even in cases of equal quantities of emissions released, levels of ambient concentration may vary, depending on meteorological, topological, and other conditions. Thus, once an ambient standard has been established, these conditions must be considered in establishing emission standards.

Community/Government

22. Invite a representative from a local or state pollution control agency to visit your class in order to discuss various pollution standards in your area and how these are enforced (e.g., how many people are involved in enforcement, how often they check for compliance, how many warnings a violator gets before fines are imposed, how large the fines are, etc.).

ACTIVITY 1

POLLUTION STANDARDS

AMBIENT STANDARDS

Ambient standards specify what is called a never-exceed level of some pollutant in the surrounding environment. These standards are normally expressed in terms of an average concentration over some period of time. For example, the current national primary standard for ozone is 240 micrograms per cubic meter on average for an hour. These standards can not be enforced directly, but they serve as guides to indicate the need for lower or higher emissions standards.

EMISSIONS STANDARDS

Emissions standards specify a never-exceed level for the quantity of emissions coming from a given pollution source. These standards are normally expressed in terms of a quantity of material per some unit of time — for example, pounds of sulfur per hour or tons of organic wastes per day. These standards are enforced through periodic monitoring.

TECHNOLOGY-BASED STANDARDS

Technology-based standards require the use of a specific technology, practice, or piece of equipment, usually established by the regulatory agency. Certain laws, for example, require cars to be equipped with catalytic converters or require electric utilities to install "scrubbers" in their stacks to reduce sulfur dioxide emissions. These standards are enforced by seeing that the mandated technology is installed and used.

ACTIVITY 2

SPEEDING STANDARDS

Answer the questions below:

a. What is the speed limit on most of the nation's non-interstate highways?

b. Why is a limit set on how fast you can drive?

c. Assuming speed limits are set to minimize the number of lives lost in traffic accidents, why isn't the limit set at five miles per hour or even lower (so that no one would be killed)?

d. Suggest a goal other than "minimizing the number of lives lost" that society may be using in setting speed limits.

e. Is the speed limit on all roads the same? Give some examples of different speed limits.

f. Why do you think the speed limits are not the same for all roads?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

EMISSION STANDARDS

Using Activities 1 and 2 as references, answer the following questions:

a. How is an emission standard like a speed limit?

b. What is the purpose of emission standards?

c. If protecting the environment is the goal, why shouldn't the maximum allowable emissions be very low or even zero?

d. If protecting the environment is not society's goal in establishing emission standards, what is the goal?

e. If society's goal is to maximize its net benefits, should the emission standard for all pollutants be the same?

f. If society's goal is to maximize its net benefits, should the emission standard for a given pollutant be the same in all areas of the country?

ACTIVITY 4

STEPS TO RECEIVING A FINE

1. The violator must be caught not complying with the standard (that is, emitting more than the standard allows).
2. The enforcement agency must gather enough evidence of this noncompliance to bring to a prosecutor.
3. The prosecutor must take the case to court and win.
4. The court must impose a fine.

Some anecdotal evidence regarding these steps:

1. "Our 1983 report . . . estimated that over 80 percent of the 531 municipal and industrial facilities we reviewed exceeded the monthly average limits of their permits at least once during an 18-month period . . . . Our 1989 report on the pretreatment program estimated that over 40 percent of 18,000 industrial users of treatment plants exceeded one or more of their discharge limits over a 12-month period."
   — R.L. Hembra, General Accounting Office, in *Water Pollution Prevention and Control Act of 1991.*

2. "Between 1971 and 1974 the State of Connecticut identified 1,469 violations of its air-pollution statutes, but only 16 cases were referred to the attorney general for prosecution."
   — Alan S. Blinder in *Hard Heads, Soft Hearts.*

3. "During a thirty-two month period ending in February 1986 [the state of Virginia] managed to obtain just one consent order and one court-ordered fine in all cases."
   — Alan S. Blinder in *Hard Heads, Soft Hearts.*

4. "A New Jersey company convicted in 1980 of discharging hydrofluoric acid into a parking lot from where it could seep into groundwater was fined a paltry $2,125. The total of air-pollution fines collected by the EPA during the four fiscal years 1977-1980 amounted to merely $27 million — less than 1/100th of 1 percent of what firms spent during those years to comply with environmental regulations."
   — Alan S. Blinder in *Hard Heads, Soft Hearts.*

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 5E

CALCULATING THE EXPECTED PENALTY

Four steps are required for a violator of an emission standard to receive a fine:

1. He or she must get caught violating the standard.
2. The enforcement agency must provide the prosecutor with evidence.
3. The prosecutor must win the case in court.
4. The court must impose a fine.

Suppose these events are independent. Determine the probability of receiving a fine in each of the following cases:

a. the probability of each step occurring is .50 (there is a 50-50 chance for completing each step).
b. the probability of step 1 is increased to .90 through the addition of "pollution cops" while each of the other probabilities is raised to .70 because of a new "get tough" attitude on the part of prosecutors and the court.
c. the court stiffens the requirements to prove noncompliance, thus reducing the probability of step 3 to .40, while all other probabilities are near .80.

Now determine the "expected penalty" in each of the above cases if the fine is:

d. $50,000
e. $20,000

Finally, assuming that the expected penalty is the only cost that the polluter considers, in which cases would it consider violating the standard if its control costs are:

f. $12,000
g. $ 5,000

ACTIVITY 6E

CHOOSING HOW TO MEET THE STANDARD

Suppose there are four ways for a firm to reduce its emissions by 50%:

Method A: Install pollution control device XJ4000. Annual cost: $25,000.

Method B: Install pollution control process KLEEN-UP. Annual cost: $20,000.

Method C: Adjust the production process so that it is more efficient in utilizing its inputs, thus reducing waste flows. Annual cost: $17,500.

Method D: Change the nature of the inputs used so that less waste is generated. Annual cost: $32,000.

Given the information above, answer the following questions:

a. If this firm must reduce its emissions by 50% to meet a new emission standard, which method will it choose? Why?

b. Suppose instead of a new emission standard requiring 50% reduction, the regulatory agency establishes a technology-based standard by requiring all firms to install pollution control device XJ4000 (which yields the desired 50% reduction). Which method will the firm choose now? Why?

c. Suppose a new pollution control technology is developed: XJ5000! It could achieve a 50% reduction for an annual cost of only $16,000. How would the firm react to this in each of the above cases?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

BUYING ENVIRONMENTAL QUALITY AT DISCOUNT PRICES

INTRODUCTION

Although we might not all agree on what the proper level of environmental quality should be, most of us probably would agree that whatever level is chosen should be attained as cheaply as possible. In this lesson students learn how the use of emission charges and tradable permit markets can achieve this result, while other regulatory approaches may not. Students also discover how "putting a price" on the use of natural resources of the environment encourages pollution control and helps to provide environmental quality.

ECONOMIC CONCEPTS

Markets
Supply
Demand
Economic Incentives
Cost Effectiveness
Emission Charges
Tradable Permits

ENVIRONMENTAL CONCEPTS

Fossil Fuels
Acid Rain
Global Warming

OBJECTIVES

- Define cost effectiveness (achieving a goal in the least-costly manner possible).
- Explain how the use of economic incentives can lead to cost effectiveness.
- Explain how emission charges and tradable permit markets may enable people to put a price on using scarce resources, the natural resources of the environment.

LESSON DESCRIPTION

Students play the role of company representatives and regulators in an attempt to reduce emissions of HW700 (a fictitious pollutant) in the least-costly manner possible. The activity shows how the use of emission charges and permit markets can help companies to achieve this result. The lesson is then applied to the wastes that result from burning fossil fuels.

TIME REQUIRED

One class period (if extra time is needed to explain the table shown in Activity 2, two periods may be necessary.)

MATERIALS

One set of company name tags and control cost cards produced from Activity 1
One copy for each student of Activities 2, 3, and 4

PROCEDURE

Isn't Cheaper Better?

1. Relate the following: Suppose the car model of your dreams is available from three car dealers who are identical in every way (reputation, service after the sale, etc.). The first offers the car for $18,000, the second for $16,000, and the third for $15,000. From which dealer would you buy the car?
   Obviously, the third.
2. Currently the nation spends around $100 billion per year for pollution control (better environmental quality). If we could get the same level of environmental quality for less money, would that be desirable?

Yes. It would free up resources to produce more of other products while maintaining the level of environmental quality.

3. Thus, a reasonable goal of environmental policy is to achieve whatever level of pollution control is desired as cheaply as possible. When this goal is attained, the method is said to be cost effective (or cost efficient — see Lesson 5). The following steps show how the cost-effectiveness goal might be attained.

Reducing HW700 as Cheaply as Possible

4. Ask four students to come to the front of the room and sit at a table or desk facing the class. Each will represent the CEO of some company. Place one company card (Widgets, Inc., Gadgets-R-Us, ACME, and Cogs, Co.) in front of each student and give each of them his or her respective control cost card (both from Activity 1). Tell students that their cost information is to be kept secret from the other CEOs and from the rest of the class. Explain that each card shows the actual cost of reducing or controlling each unit of HW700, if the firm uses the least costly options open to it.
5. Tell the class that these four firms together emit 32 tons of HW700 per day into the air. The state pollution control agency has determined that, to keep the ambient concentration of HW700 within acceptable levels, no more than 16 tons can safely be emitted. Thus, at least 16 tons (32 minus 16) must somehow be controlled.
6. Divide the rest of the class into groups of three to four. Each group represents a regulatory agency; each agency's job is to come up with a plan to reduce HW700 by 16 tons (that is, the regulators must decide how much of the 16-ton reduction is to be allocated to each firm). They must do this with no additional information concerning how much each firm is emitting or the cost to each firm of controlling its emissions. Allow 10 minutes.

   During this time be sure each CEO understands his or her control cost card. In particular, note that the card shows the cost of reducing or controlling each unit. Thus, the total cost of controlling a given amount is the sum of each of the individual amounts. CEOs will be asked to reveal their total costs of complying with the various plans presented.
7. Ask each regulatory group to report its plan or policy. Write the plans on the board. Discuss them as follows:

   Three policies are commonly reported: (1) have each firm reduce by 50%, (2) have each firm reduce by four units, and (3) require all firms to use a specified pollution control technology which reduces their emissions by 50%. Some groups may suggest that the regulatory agency auction off 16 permits to the highest bidders (each company must control any unit for which it does not have a permit) or a charge approach (firms are charged a fee for each ton emitted). For now, concentrate only on the first three options.
8. Ask each CEO to report to the class the cost to his or her firm of complying with policies (1) and (2); record the information on the board.

Firm's Costs					
Policy	Widgets, Inc.	Gadgets-R-Us	ACME	Cogs, Co.	Total Cost
1	$11,000	$10,000	$3,000	$20,000	$44,000
2	7,000	10,000	4,000	20,000	41,000

Thus, policy (2) is $3000 cheaper at attaining the reduction goal than is policy (1).

9. **Ask the CEOs and the regulators: Even though policy (3) appears pretty much the same as policy (1) (both require each firm to reduce by the same amount), why might policy (3) be more expensive? Discuss responses.**
   Firms may have other (cheaper) options available to them than simply to use the mandated technology. For example, they may be aware of alternative (and cheaper!) control technology or they may be able to adjust the nature of their output, the inputs used, or their production process itself in a way which reduces the creation of HW700 in the first place.
10. **Explain to the regulators that if they knew what the CEOs know about their costs of control, they probably could come up with an even cheaper way to achieve the pollution control goal. Distribute Activity 2 to each regulator group. Ask them to respond only to questions a-e, at this time. Allow about 10 minutes (have the CEOs wait patiently) and then discuss the answers, as follows.**
    a. $5000.
    b. $16,000 ($1000 for the 1st + $1000 for the 2nd + $2000 for the 3rd + $3000 for the 4th + $4000 for the 5th + $5000 for the 6th).
    c. $150,000 ($1000 + $3000 + $6000 + $10,000 + $15,000 + $25,000 + $40,000 + $50,000). It would not have to control the 8th, 7th and 6th tons, so it would save $115,000 ($50,000 + $40,000 + $25,000).
    d. The cheapest way is found by controlling all those tons which can be controlled for $1000 first, then all those that can be controlled for $2000, and so on. This results in the following least-cost solution for 16 tons:
    Widgets, Inc. controls four tons at a cost of $7000;
    Gadgets-R-Us controls four tons at a cost of $10,000;
    ACME controls all six of its tons at a cost of $6000;
    Cogs, Co. controls two tons at a cost of $4000.
    The total cost is thus $27,000 (= $7000 + $10,000 + $6000 + $4000).
    e. A big savings over the costs of policies (1) and (2).
11. **Continue: The problem facing regulators is how to obtain this control option without knowing the firm's cost information. If one of the groups has suggested a charge, begin to pursue that policy now. Ask each of the CEOs: How many units of HW700 would you control if you were charged $5,500 for each ton you emit?**
    Widgets, Inc. would control its first six units because it costs less to control each of these than to pay the charge. Similarly, Cogs, Co.

would control its first two units, while the other two firms would control all their emissions. Thus, 22 units would be controlled and 10 would still be emitted.

12. This is more control than the goal calls for. Ask the regulators: Should the charge be raised or lowered? Discuss briefly why it should be lowered.
13. Ask the regulatory groups to answer question (f) on Activity 2. Discuss the reasons for a charge somewhere between $3000 and $4000, like $3500.
14. Ask the CEOs how they would respond to this charge.

    They should each report the exact amount of control that was noted for the least-costly option earlier.
15. Closure: Note that any desired level of control can be achieved simply by moving the charge up or down. As the firms react to the charge, they are put in a position of figuring out the cheapest way to handle their emissions — paying to control them or emitting them and paying the charge. Thus, the least-costly method of control can be achieved without the regulators even knowing the firm's control costs.

Tradable HW700 Permits

16. Explain to the students that instead of charging for units emitted, the regulatory agency could simply decide that only 16 units can be emitted — and then issue 16 permits. Each permit would allow the firm owning it the right to emit one ton of HW700 per day. (Note that this policy may already have been suggested by one of the regulatory groups.) Ask the CEOs: Suppose the agency gave each of you four of these permits and that you are not allowed to trade them to other firms. What would be the cost of control with this arrangement?

    Widgets, Inc. would have to control 6 tons (10-4) at a cost of $16,000, Gadgets-R-Us would have to control 4 (8-4) at a cost of $10,000, ACME 2 tons (6-4) at a cost of $2000, and Cogs, Co. 4 tons (8-4) at a cost of $20,000. The total control cost would be $48,000!
17. Now suppose the firms are allowed to trade the permits among each other. Assign the CEOs to negotiate trades among themselves. Assign the regulatory groups to try to predict the outcome (have them answer question (g) on Activity 2). Allow 10 minutes. Ask the CEOs report on the trades they made; discuss the reports as follows.

    If Cogs, Co. had another permit, it could save $10,000 in control costs (the cost of controlling the fourth unit). Meanwhile, if ACME gave up one of its permits it would only have to pay $1000 to control its third unit. This gives the two firms plenty of room to negotiate. For example, Cogs, Co. could offer ACME $3000 for one of its permits. If the trade is made, Cogs, Co. saves $10,000 in control costs, pays $3000 for the permit, and comes out ahead by $7000. At the same time, ACME gains $3000 for the permit, must pay $1000 to control an additional unit of HW700, and comes out ahead by $2000. Through additional trades like these it is not difficult for the students to discover that the least-costly control result will occur again. In particular, Widgets, Inc. will end up with six permits (and would control four units), Gadgets-

R-Us will end up with four permits (and would control four units), ACME will end up with no permits (and would control all six units), and Cogs, Co. will end up with six permits (and would control two units).

18. **Suppose that, instead of simply giving the permits to the firms, the state pollution control agency puts the 16 permits up for sale, so that the quantity of permits supplied at all prices is 16. Ask each CEO to determine how many permits he or she would buy if the price were $12,000? $7500? $4500? $2500? $0? Ask the regulatory groups to answer question (h) on Activity 2. Discuss responses.**

    At $12,000, only four would be demanded — all of them by Cogs, Co. For the rest of the firms it is cheaper to reduce emissions than to buy the permit. The 5th through 8th tons for Cogs, Co. would each cost Cogs a lot more than $12,000 to control, so Cogs would want to buy the permits to avoid paying the control costs. Similarly, at $7500, Widgets, Inc. would want to buy two permits (to avoid cleaning up the 9th and 10th tons), and Cogs, Co. would want five for a total quantity demanded of seven. At $4500, Widgets, Inc. would want five, Gadgets-R-Us two, and Cogs, Co. six for a total of 13. At $2500 Widgets, Inc. would want seven, Gadgets-R-Us six, and Cogs, Co. seven for a total of 20. At $0, Widgets, Inc. would want 10, Gadgets-R-Us eight, ACME six, and Cogs, Co. eight for a total of 32.

19. **Ask the CEOs to return to their seats (and give them a copy of Activity 2). Show a transparency of Activity 3. Note that the demand curve shows the value of each additional permit to the firms (it is the amount of control costs they would avoid having to pay). Take each of the prices above, find it along the vertical axis, and read over to the demand curve and down to the horizontal axis to find the quantity of permits demanded (which equal those values above). Ask the class: What price would the market set? Answers follow.**

    Somewhere between $3000 and $4000. Above $4000, more permits are offered than are demanded, so the surplus would drive the price down. Below $3000, more permits are demanded than are available, so the shortage would drive the price up.

20. **Ask each student to answer question (i) on Activity 2. Allow five minutes and then discuss, as follows.**

    Widgets, Inc.: buy six permits, clean up four tons.

    Gadgets-R-Us: buy four permits, clean up four tons.

    ACME: buy 0 permits, clean up six tons.

    Cogs, Co.: buy six permits, clean up two tons.

    Note that this is exactly the least-costly solution found earlier; all that the regulatory agency had to know is how many tons it would allow to be emitted.

Carbon and Sulfur Taxes

21. **Homework: Assign students to complete Activity 4. Review homework as follows.**

    a. They represent a payment for the use of a scarce resource — in this case, the air — as a depository for carbon and sulfur emissions.

b. This doesn't alter people's willingness or ability to pay for electricity, so the demand curve is not affected. The costs of producing electricity would, however, rise; producers therefore would require greater compensation for a given output level. This would be shown by an upward (or leftward) shift of the supply curve.
c. The equilibrium quantity would fall while the price would rise.
d. Since less electricity is produced, the quantity of emissions also would decrease.
e. Producers are always looking for the least costly way of producing their outputs (the profit motive). If they have to pay to use the air as a depository for emissions, they will likely consider using "cleaner" fossil fuels (lower-sulfur coal, natural gas). They might also consider alternate energy sources (hydro, wind, geothermal) in an effort to avoid the emission taxes altogether.

EXTENSION ACTIVITIES

Economics

22. **While economic approaches (emission charges and tradable permits) can be quite cost-effective, businesses tend to prefer a standards approach (see Lesson 13). They argue that the economic approaches are actually more expensive. How can this be? Assign students working in groups to explain this. Discuss answers in class.**

    With a charge or permit system, firms must pay not only for the emissions they control, but also for the emissions they don't control (paying the charges or buying the permits). With the standards approach they must only pay the control costs. Note that most permits are not auctioned; they are initially given to emitters, based on some allocation scheme. This lowers the cost of the permit system to emitters, yet it yields the least-cost result if the permits can be traded.

Government

23. **Assign students to investigate the use of economic incentives by their state pollution control agency. This approach has been fairly slow to develop. Students should suggest reasons for this from the perspective of these agencies.**

    A major barrier has been the lack of effective monitoring devices and enforcement. These inadequacies are, however, also problems with a standards approach, which explains why the tendency to mandate certain types of control technology has been so popular (yet not very cost-effective, as was noted by the analysis of policy (3).

ACTIVITY 1

CONTROL COST CARDS

Widgets, Inc.

Cost of Reducing Each Additional Ton of HW700

Ton	Cost
1st	$1000
2nd	1000
3rd	2000
4th	3000
5th	4000
6th	5000
7th	6000
8th	7000
9th	8000
10th	9000

Gadgets-R-Us

Cost of Reducing Each Additional Ton of HW700

Ton	Cost
1st	$2000
2nd	2000
3rd	3000
4th	3000
5th	4000
6th	4000
7th	5000
8th	5000

ACME

Cost of Reducing Each Additional Ton of HW700

Ton	Cost
1st	$1000
2nd	1000
3rd	1000
4th	1000
5th	1000
6th	1000

Cogs, Co.

Cost of Reducing Each Additional Ton of HW700

Ton	Cost
1st	$1000
2nd	3000
3rd	6000
4th	10000
5th	15000
6th	25000
7th	40000
8th	50000

ACTIVITY 1

COMPANY NAME TAGS

WIDGETS, INC.	GADGETS-R-US
ACME	COGS, CO.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE COSTS OF CONTROLLING HW700 EMISSIONS

The table below shows the cost of controlling each additional ton of HW700 emissions for the four firms that generate it. Answer the questions following the table.

COST OF REDUCING EACH ADDITIONAL TON OF HW700 EMISSIONS

Ton of HW700	Widgets, Inc.	Gadgets-R-Us	ACME	Cogs, Co.
1st	$1000	$2000	$1000	$1000
2nd	1000	2000	1000	3000
3rd	2000	3000	1000	6000
4th	3000	3000	1000	10000
5th	4000	4000	1000	15000
6th	5000	4000	1000	25000
7th	6000	5000		40000
8th	7000	5000		50000
9th	8000			
10th	9000			

a. How much would it cost Widgets, Inc. to control its sixth ton of emissions of HW700?

b. How much would it cost Widgets, Inc. to control six tons of emissions of HW700?

c. What would it cost Cogs, Co. to control all of its emissions? How much would Cogs save if it was allowed to emit three tons?

d. What would be the least-costly way for these four firms to control 16 tons (how much should each firm control)?

e. How does the total cost of controlling 16 tons you found in (d) compare with the costs resulting from the other policies discussed in class?

f. What emission charge per ton would result in 16 tons of HW700 being controlled by the firms?

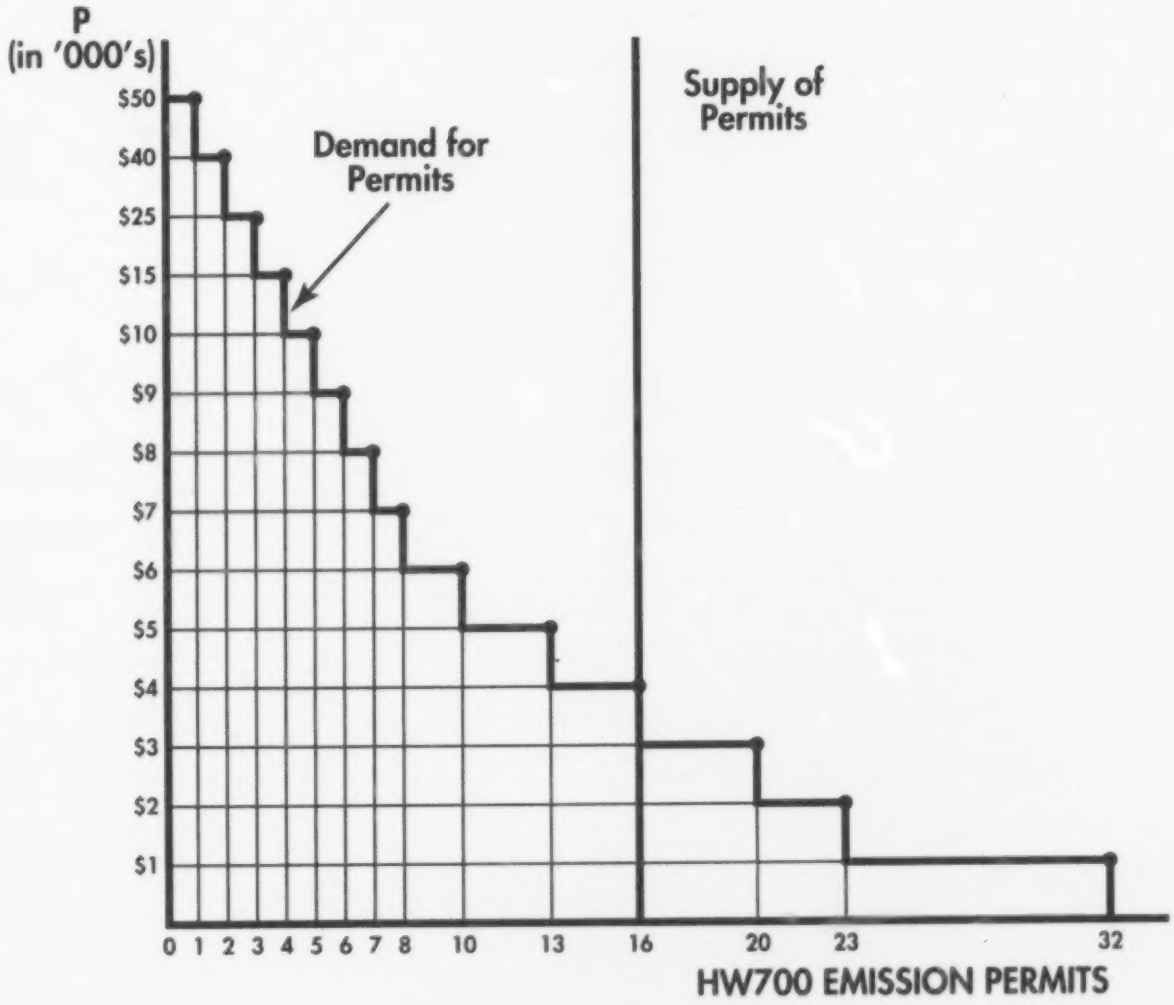
g. If each firm starts with four permits but is allowed to buy and sell these permits amongst themselves, what trades would likely occur and how many permits would each firm end up with?

h. How many permits would be demanded by each firm (and in total by all firms) at each of the following prices:
   $12,000
   $7,500
   $4,500
   $2,500
   $0

i. Suppose the price of permits is $3800. How many would each firm buy and how many tons of HW700 would each control?

ACTIVITY 3

THE MARKET FOR EMISSION PERMITS



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

PAYING TO USE A SCARCE RESOURCE: CARBON AND SULFUR TAXES

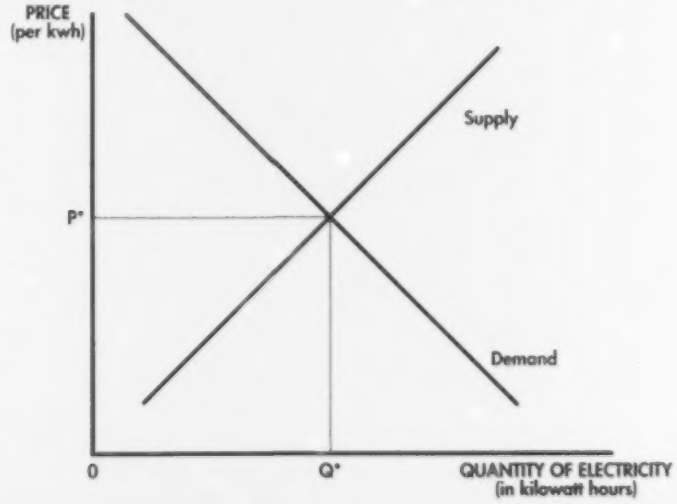
Consider the market for electricity as depicted by the supply and demand curves shown below. The demand curve reflects what consumers are willing and able to pay for electricity while the supply curve reflects the costs of the resources used to produce electricity (for example: natural (oil, coal, natural gas), capital (power plant, transmission lines, maintenance trucks), and human (coal miners, technicians, managers, engineers)).

If a fossil fuel is burned to create the electricity, virtually all of the fuel exits as emissions from the power plant in the form of gases and particulates, including carbon dioxide and sulfur dioxide. Carbon dioxide has been identified as a potential culprit in global warming. Sulfur dioxide emissions can lead to acid rains. In other words, these emissions may result in the loss of some environmental quality. The value of this loss of environmental quality is thus another cost to society of producing electricity. Without some kind of intervention, however, this cost would not likely be reflected in the supply curve for electricity.

Suppose now the government places a tax on each pound of carbon emitted and another on each pound of sulfur emitted.

Given this, answer the following questions:

a. How are these taxes like the payments for the other resources used in the production of electricity?
b. How would these charges affect the demand and/or supply curves below?
c. How would this affect the equilibrium quantity of electricity produced and its equilibrium price?
d. How would this affect the amount of carbon and sulfur emissions?
e. How might these charges lead to changes in the way electricity is produced?



UNIT 6

THE MANAGEMENT OF NATURAL RESOURCE STOCKS

HALLOWEEN TREATS AND NONRENEWABLE RESOURCES

INTRODUCTION

In any economic system, people must decide what to produce, how to produce it, when to produce it, and who will get it. This lesson looks at the "when" question. In particular, if society has only a finite amount of some resource, when should that resource be used — today, tomorrow, or not at all? This problem is sometimes called the "cake-eating" problem: given a cake (with good preservatives!), what is the best way to eat it all at once, a little each day, or by some other pattern of consumption? In this lesson students learn how people making decisions in the market for a nonrenewable resource decide when the resource will be used; they also learn how the price of the resource reflects its growing scarcity.

ECONOMIC CONCEPTS

Nonrenewable Resources
Assets
Interest Rate
Price
Rate-of-return
Capital Gain

ENVIRONMENTAL CONCEPTS

Fossil Fuels
Solar Energy

OBJECTIVES

- Describe the characteristics and give examples of nonrenewable resources.
- Consider the economic question of "when" a resource should be used.
- Discover nonrenewable resource owners' incentives not to sell all of their resource today.
- Describe the role of interest rates in the determination of prices for natural resources over time.
- Explain the role of rising prices in mitigating the effect of "running out" of a resource.

LESSON DESCRIPTION

Students are introduced to the "when" question with a Halloween variation of the "cake-eating" problem. The snacks described in the problem are then used to demonstrate how a market for a nonrenewable resource works. The lesson culminates with a look at how the rising price of nonrenewable energy resources encourages the development of solar energy.

TIME REQUIRED

One class period

MATERIALS

One small packet of nutritious snack food (e.g., raisins, nuts, dried fruit) for each student
One copy for each student of Activities 1, 2, and 3

PROCEDURE

Halloween Treats

1. Relate the following story to the class: Clark has just returned from a most successful Halloween outing. He has collected nearly 200 wholesome Halloween treats. Each of the treats is well-packaged and should last for a long time. Clark's mom in a moment of parental carelessness tells Clark that he may eat his treats whenever he wants. Ask: How do you think Clark should eat his treats over time? Discuss responses.

Many responses are possible: one-a-day for 200 days, all today, a lot today/a little tomorrow, etc. Note the hidden criterion students typically use for defining "should." They will usually speak in terms of Clark getting the most satisfaction (or value) out of the treats (the economic criterion of allocative efficiency — see Lesson 5). They will also probably mention that saving some of the treats for the future is desirable, since a treat might be worth more to them later ("diminishing returns").

2. **Ask: How are Clark's treats like nonrenewable resources? Discuss responses.**

   Assuming Clark can't get any more treats, there is only a finite amount available; using (eating) any of the finite amount means less will be available in the future.

3. **Ask: How are his treats different from nonrenewable resources?**

   The treats are produced goods — the total amount available could be increased (more produced or obtained through another Halloween outing). Nonrenewable resources are "produced" by the environment, but new quantities are produced at such a slow rate (e.g., millions of years to convert dead plant life to oil) that for all practical purposes the quantity available cannot be increased.

4. **Ask the students to provide some examples of nonrenewable resources.**

   Fossil fuels (coal, oil, natural gas) and minerals (lead, zinc, copper, tin, iron ore, etc.) are the most obvious.

5. **Relate this back to Clark's problem and ask: How should these resources be used over time? Discuss responses.**

   You should get similar responses to those above; however, you might also note a more cautious, conservation-oriented attitude (that is, the need to save some for future generations).

The Coil Market

6. **Distribute a snack pack to each student in the class. Relate the following: Each of you is now the proud owner of one unit of "coil," a nonrenewable, nonrecyclable energy resource. These units are the only ones that exist. Thus, the total stock of coil in the world is X (where X is the number of students in your class).**

7. **Distribute a copy of Activity 1 to each student (or show it as a transparency). Continue: Suppose that the demand for coil today and one year from today (the "future") is the same. Further assume there is no demand whatsoever for coil beyond these two periods. Your goal as a holder (owner) of coil is to get as much as possible for your unit. In a moment today's coil market will open and all of you who wish to sell your coil today will be asked to hold your unit of coil up. The market will stay open for about a minute, in which time any offer to sell can be made or withdrawn. At the end of the minute, all sales will be binding. The only other time you will be able to sell your coil will be in the second period (the "future"). Clarify the task as necessary, emphasizing that the exact number of units available ("X") and that no more will be discovered or found. If necessary, you might also review how to "read the demand curve" (that is, note that at a price of $3, 20 units are demanded, while at a price of $2, 30 units are demanded, etc.).**

8. Announce that today's market for coil is open, and remind students to hold their coil up so you (and everyone else) can see their offer to sell. During the minute in which the market is open, keep announcing how many coil are being offered for sale so that all students are aware of the amount.

   Students typically begin to realize that if more (less) than half of the units are offered, it is better (worse) to wait until the next period to sell. A lower (greater) quantity supplied then would yield them a higher (lower) price. By the end of a minute, typically, half the units are being offered. If not, record the number offered on the board and show how the prices in the two periods would compare (assuming everyone else is selling in the second period). Discuss the incentives that any price difference creates as noted above.
9. Ask the students to find the quantity supplied in each period (which should be half of X) along the horizontal axis of each demand curve in Activity 1. Ask them to draw a vertical line at this amount, to represent the supply of coil in that period. Finally, ask them to report on what the price would be in each period. Discuss responses.

   Given that the quantity supplied in each period is the same, the prices would be also. For example, in a class of 40 (X=40), 20 units would be offered each period so that the price in each period would be $3.
10. After noting that about half of the coil is offered in each period, ask the class how much they would expect to be offered in each period if there had been three, four, or more periods with equal demands. Answers follow.

    Three periods: one-third; four periods: one-fourth; n periods: one-nth.
11. Ask: How would the prices in the three-period case (with three similar demand curves) compare with those in the two-period case? Discuss responses as follows.

    Since only one-third of X would be supplied in each period versus one-half, the price would be higher in each period. You might appeal to students' intuition by noting that the total supply over time is still X, but with three periods of demand the total demand over time is greater. Thus, as typical supply and demand curves show, a greater demand with supply held constant leads to a higher price.
12. Returning to the two-period case ask: How would the prices in the two-period case have changed if each of you had been given two units of coil? Discuss responses.

    Since X would be twice as much, twice as much would have been offered in each period, and the prices would have been lower. Again — appealing to students' intuition — you might note that the total supply over time was increased while the total demand over time remained the same. Thus, as typical supply and demand curves show, a greater supply with demand held constant leads to a lower price.
13. Close out this discussion by noting that price is supposed to be a measure of scarcity. Ask: As the nonrenewable resource is used and less of it is available (it is more scarce), shouldn't its price be rising?

    Yes.
14. Challenge students to see if they can come up with what is missing from the exercise above.

    One factor would be the cost of actually extracting the resource,

which is implicitly assumed to be zero in the activities of this lesson. However, as minerals are extracted, for example, the quality of the remaining ore tends to fall, and miners must dig deeper and process more ore to get the same amount of mineral. These "extraction" costs raise the price of the mineral (although it might be noted that, historically, technological advances in mining have offset these increases somewhat). Another important factor will be demonstrated in the step below: the opportunity cost of holding on to the resource.

Getting a Return on an Asset

15. **Distribute Activity 2 to each student. Discuss with students the definition of "rate-of-return." Note that assets can provide two general types of return: a change in the price of the asset itself (called a "capital gain" if the price goes up and a "capital loss" if it goes down) and an income flow (interest payments, dividends, etc.). Assign the students working in groups to complete Activity 2. After 10 minutes, discuss answers:**
    a. House: 5.6%, (52,800 - 50,000 + 0)/(50,000)
    b. Savings Deposit: 5.0%, (10,000 - 10,000 + 500)/(10,000)
    c. Stock: 7.5%, (4200 - 4000 + 100)/(4000)
    d. Bond: 6.0%, (19,200 - 20,000 + 2000)/(20,000)
    e. Cash: 0.0%, (1000 - 1000 + 0)/(1000)
    f. Mineral Rights (Coal): 4.0%, (104,000 - 100,000 + 0)/(100,000)
16. **Ask: What kind of return is possible from holding on to (not selling today) a nonrenewable resource such as coil?**
    A possible capital gain, if the resource can be sold at a higher price in the future — note this was the case for the coal mineral rights in Lesson 15, Activity 2.
17. **Note in the two-period coil market that the prices in both periods were the same. Ask: What return would be earned by those who waited until the second period to sell?**
    0%, as there was no change in the coil's price.
18. **Ask: Would this be acceptable to the people who were waiting until the second period to sell?**
    No. They would be better off selling in the first period and then using the proceeds to buy an asset which yields a better return.
19. **Ask: What would they likely do?**
    Start offering their coil in the first period.
20. **Ask: What would the effect of this be on the prices in each period?**
    The price would start to fall in the first period and rise in the second.
21. **Finally ask: How far will the two prices move apart?**
    Note that as the prices in the two periods begin to spread apart, a capital gain would exist, and some might now consider waiting until the second period to sell. If the spread in the prices becomes great enough, the rate-of-return from waiting to sell could become so attractive that more people begin to wait until the second period to sell. Eventually, a balance would be obtained where the prices in the two periods would be r% apart, where r is the going rate-of-return on other assets of similar risk.
22. **Thus, assuming there are no extraction costs, the price of a nonrenewable resource would rise**

over time at a rate of r, reflecting its growing scarcity.

Ask students to determine what would happen to the quantity supplied in each period if the price in the second period were r% higher than that in the first period.

The quantity supplied in the first period would be greater as long as the demands in both periods were the same. This suggests a declining consumption path over time or, in Clark's case, that he eats a lot today, a little less tomorrow, a little less the next day, etc. The important point here is that nonrenewable resource holders have an incentive to wait to sell their resource; it is not all used up today, but instead its use is spread out over time.

Solar Energy

23. Distribute Activity 3. Have students read it. After 10 minutes, discuss the responses as follows.
    a. First, it is still less costly and more convenient to use fossil-fuel-based energy. Second, a major problem with solar energy is that it is not available at night or on cloudy days. Thus, it must be stored when it is available. Unfortunately, efficient storage methods are still lacking and/or fairly expensive.
    b. As cheap-to-extract fossil fuels become more scarce, their price will rise, making solar options more competitive. You might also note that rising fossil fuel prices will also encourage increased conservation.

EXTENSION ACTIVITIES

Math

24. The simple two-period case can be used as an application of solving simultaneous equations. Explain that two conditions must be met to find the equilibrium prices and quantities:
    a. Total Quantity Supplied = Total Quantity Demanded, or X = Q1 + Q2 (where Q1 is the quantity demanded in the first period and Q2 is the quantity demanded in the second period)
    b. Price must rise by r% each period or, P2 = P1(1+r) (where P1 is the price in the first period and P2 is the price in the second period)
    If the demand in each period is given by P1 = a - bQ1 and P2 = a - bQ2, then by substitution (b) may be written as:
    a - bQ2 = (a - bQ1)(1+r) or ar/b = (1+r)Q1 - Q2.
    Thus, there are two equations and two unknowns:
    X = Q1 + Q2 and ar/b = (1+r)Q1 - Q2.
    These may be solved by substitution or elimination. Once the Q values are determined, the demand equation can be used to find the prices.
25. Ask the students to use the above equations to find the quantities and prices in each of the following cases, and to draw some general conclusions by comparing each case to case (a):
    a. a = 10, b = .01, r = .10, X = 1000.
    b. a = 10, b = .01, r = .20, X = 1000.
    c. a = 10, b = .01, r = .10, X = 1500.
    d. a = 15, b = .01, r = .10, X = 1000.
    Discuss answers:
    a. Q1 = 523.8, Q2 = 476.2, P1 = $4.76, P2 = $5.24
    b. Q1 = 545.5, Q2 = 454.5, P1 = $4.55, P2 = $5.46

Higher interest rates lead to more use in the earlier period; prices are 20% apart, so today's price is lower.

c. Q1 = 761.9, Q2 = 738.1, P1 = $2.38, P2 = $2.62

Greater resource availability leads to lower prices (this is the effect of new discoveries on prices).

d. Q1 = 547.6, Q2 = 452.4, P1 = $9.52, P2 = $10.48

Greater demand leads to higher prices.

Science

26. Assign students to investigate how their own homes or apartment buildings could be adapted or remodeled to use passive solar energy more effectively. In this investigation they should research the requirements of a passive system, consider alternative designs, and design and draw an illustration of the necessary adaptation for their home or apartment building. They also should estimate the cost of this adaptation and estimate the cost-savings they anticipate. There are many "how-to" books which describe solar adaptations; in addition, you could invite a speaker from a business which sells solar equipment to meet with your class.

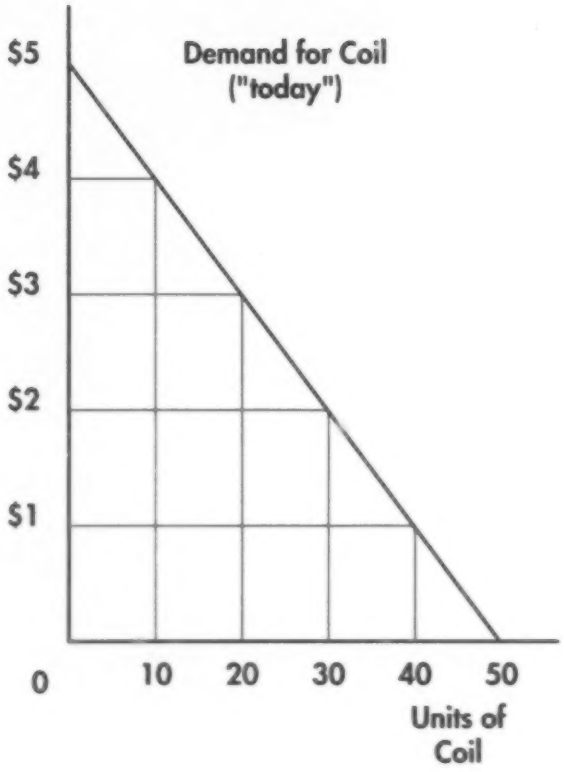
Economics

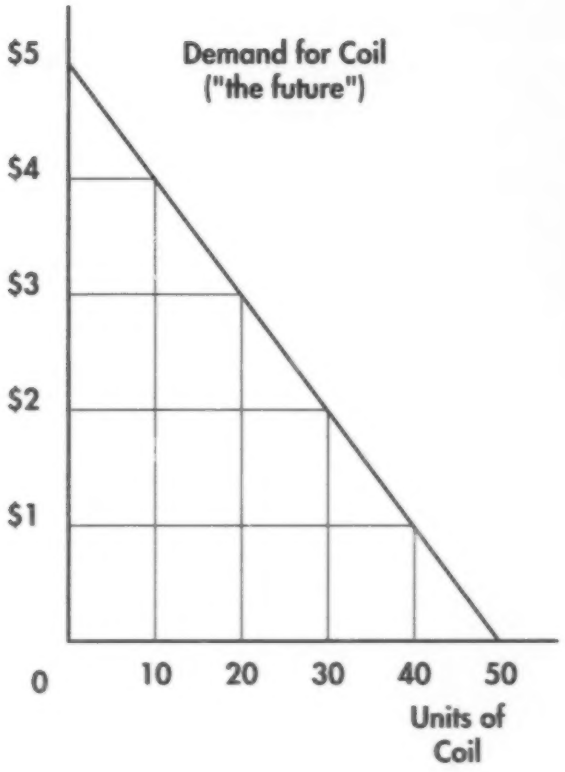
27. In the simple case where the interest rate was assumed to be zero, assign students to show that the resulting allocation of the X units of coil (half in each period) is in fact that which maximizes the value society receives from it (that is, it is allocatively efficient). Lead them by asking: what would happen to the total value society receives from the coil if one unit were transferred between the two periods? Discuss responses as follows.

Suppose X=40 so 20 units are offered in both periods. Suppose now one unit is moved. The loss of the 20th unit in the period it is taken from would be $3 (the value of the 20th unit read from the demand curve in Activity 15.1). The gain of a 21st unit in the second period would be slightly less than $3 (actually, given the linear nature of the demand curve, about $2.90). Thus, the market allocation is allocatively efficient. Note that this would also be true in the case where a positive rate-of-return is assumed.

ACTIVITY 1

THE USE OF COIL OVER TIME





From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE RATE-OF-RETURNS ON ASSETS

Given the following definition:

$$\text{Rate-of-Return} = \frac{\text{(Value of the Asset Today - Value of the Asset a Year Ago + Any Income Generated)}}{\text{Value of the Asset a Year Ago}}$$

determine the rate-of-return on each of the following assets:

a. A house worth $50,000 today which will sell for $52,800 a year from today.

b. $10,000 in a savings account which pays 5% simple annual interest.

c. 100 shares of IBN stock which had a price per share of $40 a year ago, a current price of $42, and paid a dividend of $1 per share.

d. A bond with a face value of $20,000 which was purchased a year ago for $20,000, pays 10% interest on its face value each year, and is currently selling for $19,200.

e. $1000 in cash placed in a mattress a year ago.

f. Mineral rights over 10,000 tons of coal which sold for $10.00 per ton last year and $10.40 per ton today.

ACTIVITY 3

SOLAR ENERGY

While cheap-to-extract nonrenewable fossil fuels are limited, the sun should last for several billion more years (relax, that's billion, not million!). What's more, the amount of solar energy striking the United States alone is hundreds of times greater than the total energy the nation consumes. This seemingly limitless source of energy can be tapped directly in three ways: passively, actively, or through the use of photovoltaics.

Passive systems are based on simply building structures in a way that takes advantage of the sun. Large, south-facing windows are installed to allow the sun to heat interior walls and floors built to store this heat (typically brick or concrete). At night and on cloudy days, this heat is radiated into the room. In addition, the structure should be well-insulated, with the windows covered at night to minimize heat loss. Passive systems are most cost-effective if these features are built into the original design of a home, although retrofitting existing homes with "solar rooms" is often possible.

Active heating/cooling systems are based on collectors — usually mounted on the roof of buildings. The black materials inside these collectors absorb the sun's heat and transfer it to water flowing through pipes in the collector (air and a fan can also be used). The water is carried to a well-insulated storage tank for space or water heating. Such systems can be added to existing homes fairly easily, but the additions do entail some equipment, plumbing, and aesthetic (the presence of the collectors themselves) costs.

Photovoltaics ("solar cells") are thin wafers of silicon or other material. They generate electricity as the sun's ray strike the material, causing it to emit electrons. Electricity generated in this way is more costly now than electricity generated from conventional, fossil-fuel-based sources, but technological improvements are constantly lowering the cost of the photovoltaic option.

a. Why hasn't there already been a massive switch from fossil fuels to solar energy?

b. How is this likely to change in the future (keeping in mind that fossil fuels are nonrenewable resources)?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

THE EXTINCTION OF CHICKENS AND MOSQUITOS — NOT!

INTRODUCTION

Why are blue whales, grizzly bears, and rainforests threatened with extinction, but not chickens (which are being consumed in ever-increasing numbers by health-conscious people) or mosquitos (which many people believe, rightly or wrongly, we would all be better off without)? Whales, bears, and rainforests all are renewable resources that can grow over time and replenish themselves; it should therefore be possible to sustain their numbers at stable levels. We just have to make sure the amount harvested each year does not exceed the growth. In this lesson students consider the economic incentives associated with managing a renewable resource stock and the forces which can lead to the extinction of a species.

ECONOMIC CONCEPTS

Renewable Resources
Common Property Resources
Economic Incentives

ENVIRONMENTAL CONCEPTS

Biological Growth
Extinction
Sustained Yield
Species

OBJECTIVES

- Describe the nature of biological growth and its limits.
- Explain the economic incentives associated with in the management of renewable resources.
- Explain the role of common property ownership in species extinction.
- Discuss some legal, economic, and technical approaches to species preservation.

LESSON DESCRIPTION

The nature of biological growth is demonstrated with basic growth curves. These are used to show the incentive resource owners have to not harvest their resource too quickly and to maintain the size of their resource stock. Students play the role of harvesters in a game which demonstrates the "tragedy of the commons." Finally, some suggested solutions to species preservation are considered, including a stop at Jurassic Park.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-10
Day 2: Steps 11-18 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 2, 3, and 4
50 paper clips
50 dimes
A roll of masking tape
Space! (an area of the floor at least six feet by six feet)

PROCEDURE

The Growth of Biological Resources

1. Define *renewable resources* as natural resource stocks which can supply a replenishable flow of services. Ask students to provide some examples based on this definition. Discuss responses.

   Plant and animal species in general (forests and fish in particular), solar energy, water, soil.

2. **Ask: Does an individual tree or fish grow forever?**
   No. Each eventually dies.
3. **Ask: Can the total amount of an animal species grow forever?**
   No. A species is limited by environmental constraints: water and food supply, habitat availability, and disease brought on by overcrowding.
4. **These limits mean that the flow of services from these resources must also have limits. To illustrate these limits and the nature of growth, distribute a copy of Activity 1 to each student. This activity shows the typical pattern of growth for a stand of trees over time. Ask students working in pairs to complete the activity. Allow 15 minutes and then discuss their answers in class.**
   a. 20, 50, 70, 80, 120, 160, 100, 50, 30, 20, -20, -30
   b. First volume increases by increasing amounts; then it increases by decreasing amounts until it finally starts to actually decrease.
   c. Trees toppled by age, wind, or disease are not counted in the "standing" volume.
   d. 20.0, 11.1, 6.7, 4.4, 4.3, 3.8, 1.8, 0.8, 0.5, 0.3, -0.3, -0.5
   e. The average rate of growth tends to fall over the life of the stand.
5. **Next distribute a copy of Activity 2. This activity shows the relationship between the growth of a biological population (such as salmon or deer) and the size of its stock. Ask students (continuing to work in their pairs) to complete this activity. Allow 15 minutes and then discuss their answers in class.**
   a. 157 (150+7) tons; 110 (100+10) tons; 57 (50+7) tons.
   b. 15 and 200 tons.
   c. 200 tons. As the population approaches this amount the growth each period starts slowing to zero — the environmental constraints (difficulty finding food, overcrowding, easier to pass diseases) begin to offset the natural increases.
   d. Extinction — the stock size falls to zero. With such small populations it is difficult to find mates and compete with other species. Note that "extinction" here refers only to this habitat — not necessarily to total extinction of the species.
   e. 100 tons. At this level 10 tons could be harvested forever while leaving the stock size permanently at 100 tons.

When to Cut the Trees?

6. **Students often believe that resources, including renewable ones, will be exploited (possibly even to extinction) because people can gain economic rewards from selling them. What students too often overlook is the economic rewards resource owners can gain from not selling their resources.**
7. **With the students referring to Activity 1, ask the following questions:**
   Suppose this stand of trees is 10 years old. What does the owner gain from waiting 10 years to harvest her trees?
   500 more cubic feet to sell.
   Should she wait?
   If the value of the stand is growing at a greater rate than the interest rates paid on money in the bank or other assets (see Steps 15-22 in

Lesson 15), then yes. Note that the value of the stand (S) equals the net price (NP) of each cubic foot (price minus harvesting cost) times the volume (V) or S = NP x V.

8. **Suppose the net price is expected to remain stable into the future. When will she likely harvest this stand if the going interest rate in the economy is 5%?**

   At age 30. The rate of change in the value of the stand is just the growth rate of the stand. Up through 30 years this is greater than 5%, but for those years beyond 30 it is less.

9. **Suppose the net price is expected to rise by 2% over the coming years due to increased demand. When will she likely harvest this stand if the going interest rate is still 5%?**

   At age 60. The rate of change in the value of the stand is now its growth rate plus 2% (the rate of change in the net price). Up through 60 years this is greater than 5%, but for those years beyond 60 it is less. Note that the higher expected prices in the future (which indicate greater relative scarcity) delay harvesting until those periods.

10. **Summarize: for two important economic reasons, resource owners don't simply harvest their resources as soon as they get their hands on them: (1) resources grow ("pay interest"), and (2) resources may be more scarce in the future and hence command a higher price later.**

Harvesting the Stock

11. **Distribute Activity 3. Assign students working in pairs to complete this activity by referring to Activity 2. Allow 15-20 minutes and then discuss students' answers (if time is limited, fill in the table in (a) before making and distributing copies of this activity) as follows.**

Answers for a:

Stock Level Maintained	Annual Income From Initial Sale	Annual Income From Harvest	Total Annual Income
0	$10,000	$0	$10,000
25	8,750	04,000	12,750
50	7,500	7,000	14,500
75	6,250	9,000	15,250
100	5,000	10,000	15,000
125	3,750	9,000	12,750
150	2,500	7,000	9,500
175	1,250	4,000	5,250
200	0	0	0

b. Initially harvest 125 tons and then maintain stock at 75 tons.
c. Initially harvest 100 tons and then maintain stock at 100 tons. Harvest income values double so that at 100 tons the annual income from the initial sale is $5000 (as before) and the annual income from harvest is $20,000 for a total of $25,000 — the largest in this case.
d. Initially harvest 150 tons and then maintain stock at 50 tons. Annual income from initial sale values double so that at 50 tons the annual income from initial sale is $15,000 and the annual harvest income is $7,000 (as before) for a total of $22,000 — the largest when the interest rate is 10%. At 20% the greatest income is earned by harvesting the entire stock all at once.
e. From (c): The greater the growth rate of the resource, the closer the stock size is maintained at its maximum sustained growth level by a profit-maximizing resource holder.
From (d): The greater the interest rate, the lower the stock size maintained — possibly even to zero.

12. **Note that these results ignore the costs of harvesting. Ask students how the costs of harvesting a whale are likely to change as the stock size of whales changes? Discuss responses.**
Smaller stock sizes make the whales more difficult to find and thus more expensive to harvest. Similarly, a smaller stock size for a species of fish means each cast of a net brings in fewer fish, so more casts and more time (greater costs) are required. This suggests a third economic reason to maintain a resource stock: keeping a larger stock size lowers the cost of harvesting. In general, the larger the influence on the cost of harvesting, the greater is the stock size the resource owner would choose to maintain — even a stock size larger than the maximum sustained yield stock level (100 tons on Activity 2).
13. **Note in closing out this section that resource growth, higher future prices (likely with increased demand), and rising harvesting costs as a stock size is reduced all work to reduce the likelihood of resource owners depleting a stock of a renewable resource.**

Extinction

14. **Explain that two principal causes of species extinction are (1) harvesting (for commercial, sport, or survival purposes) and (2) habitat alteration or elimination. Then comment on (1), "But wait, didn't we just show that extinction is not usually in the best interest of resource owners? Yes, but what if there are no resource owners!"**
15. **Demonstrate the "tragedy of the commons" by reference to Steps 12-24 in Lesson 6. Note afterwards that when no resource owner is in control of the stock, the rewards from maintaining a stock and waiting to harvest it can not be captured by anyone, so the resource is exploited. Chickens are not threatened with extinction — because they are owned by someone. Whales and black rhinoceros are not so lucky.**
16. **With respect to habitat alteration, note that habitat preservation has**

the characteristics of a public good, implying that its value is likely to be understated in markets (see Lesson 7 for activities that illustrate this). Thus, other uses of the land often will prevail.

Solutions

17. Ask students to suggest some possible solutions to species preservation. Discuss responses.

    Some possibilities include better definition and enforcement of property rights (develop fish or whale "ranches"); habitat preservation through law (the Endangered Species Act) or direct purchase (for example, the Nature Conservancy is a non-profit organization which uses contributions to buy wildlife preserves); improved wildlife management (provide greater incentives to turn in poachers and greater disincentives to poach — stricter penalties and better enforcement).

18. Finally distribute Activity 4 to each student. Discuss the question raised at the end. Close by noting that the ability of mosquitos to survive in many different environments (back to the age of dinosaurs!), coupled with their lack of commercial value, make their extinction, although arguably desirable, very unlikely!

EXTENSION ACTIVITIES

Science

19. Assign each student in the class to choose a different species from the U.S. Fish and Wildlife Services' endangered or threatened species list. Each student should prepare a report on his or her species' current habitat range, its habitat requirements, its commercial or sport value, and its prospects for future survival.

Geography

20. In the 1920s trees were being cut down about twice as fast as new trees were growing in the United States. Today the growth of forests exceeds annual harvests by about one-third. In fact, there are more trees in the U.S. today than at any time since the turn of the century (although the type/mix of trees has changed somewhat). Assign each student to select a state and prepare a report on the type of trees which make up the forests in that state, what portions of the forests are owned by various groups (private landowners, timber companies, the government, native American tribes, etc.), and the importance of the timber industry to the state economy (number of jobs, income generated, tax revenues generated, etc.). The best sources for this information would be the state's department of natural resources, local logging associations, or timber companies.

ACTIVITY 1

FOREST GROWTH

Forest growth is measured in terms of volume of standing trees. When trees are young, the growth in volume is often slow (although trees can grow tall very quickly). As trees mature, volume expands more rapidly and then slows or stops. While the actual growth of a stand of trees depends on several factors (weather, soil conditions, mix of trees, disease, etc.), the chart below shows a typical pattern.

Age of Forest	Volume (cubic feet)	Average Annual Increase in Volume	Average Rate of Growth
10	200	20	20.0%
20	700	50	11.1
30	1400	___	___
40	2200	___	___
50	3400	___	___
60	5000	___	___
70	6000	___	___
80	6500	___	___
90	6800	___	___
100	7000	___	___
110	6800	___	___
120	6500	___	___

a. Fill in the "average annual increase in volume" column (as an example, in the 10 years between age 10 and age 20, the volume increased from 200 to 700 cubic feet — an increase of 500 cubic feet in ten years. The average annual increase is thus, 500/10 = 50 cubic feet per year).

b. Describe how volume changes over time based on what you found in (a).

c. What could explain the volume falling after the stand is over 100 years old?

d. Fill in the "average rate of growth" column (as an example, in the 10 years between age 10 and age 20 the average annual increase was 50 cubic feet (from (a)). The average size of the volume was 450 [(200+700)/2] cubic feet. The average rate of growth is, thus, 50/450 = .111 or 11.1%.)

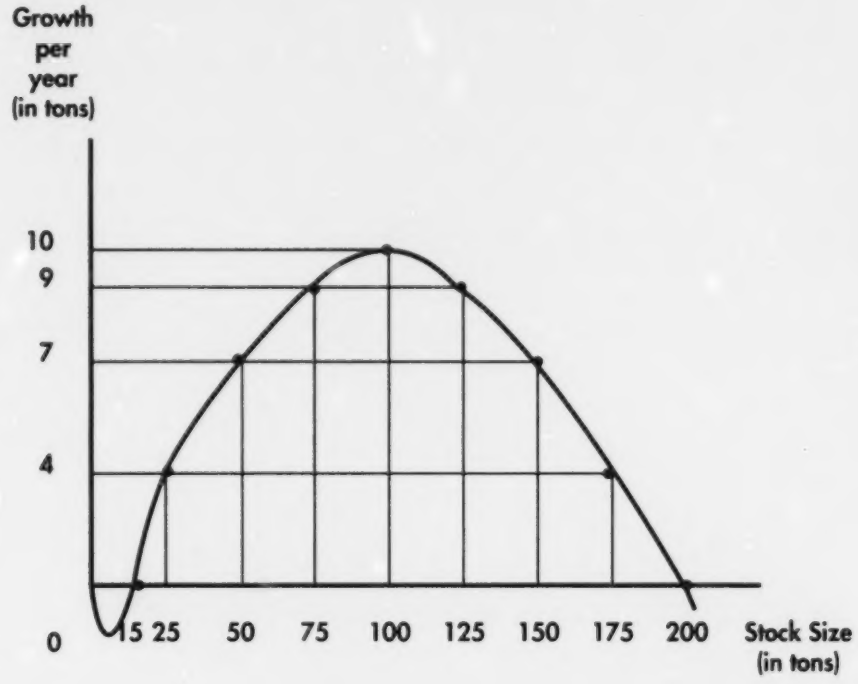
e. Describe what happens to the average rate of growth over time based on what you found in (d).

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

ACTIVITY 2

BIOLOGICAL GROWTH CURVE

The figure below illustrates the growth of a typical biological population (tuna, deer, grizzly bears) in an environment or habitat of a given size. Basically it says that the growth of such a population depends on the size of the stock relative to the size of its habitat. Based on this curve, answer the questions below.



a. What will be the size of the stock next year if the current size is 150 tons? _____
... 100 tons? _____
... 50 tons? _____

b. At which stock sizes is growth zero (i.e., weight gains and births are exactly offset by deaths)? _____

c. If the size of this stock was initially somewhere between 15 and 200 tons and was simply "left alone" for many years, how large would it eventually be? _____

d. If the stock size falls below 15 tons, what is the likely result? _____

e. Which stock level could provide the greatest sustainable harvest (the same harvest year after year after year)? _____

ACTIVITY 3

SUSTAINED YIELD OR EXTINCTION?

Given the growth curve shown on Lesson 16, Activity 2 and the conditions listed here, answer the questions below.

1. Current stock level is at its "natural" equilibrium level of 200 tons
2. The going price for this resource is $1000 per ton.
3. The costs of harvesting the stock are virtually zero.
4. Interest rate is 5%.
   a. Calculate the annual income to be earned by maintaining this stock at each of the levels shown in the table below. (As an example: if the resource owner wishes to maintain a stock of 75 tons, he or she can initially sell 125 tons (200-75) for $125,000 (125 x $1000). If this sum was deposited in a bank or invested in some other asset paying 5% interest, it would generate an annual income of $6,250 ($125,000 x .05). In addition, the resource owner could harvest the growth from his or her stock each year (9 tons) for $9,000. The total annual income would then be $15,250).

Stock Level Maintained	Annual Income From Initial Sale	Annual Income From Harvest	Total Annual Income
0	_____	_____	_____
25	_____	_____	_____
50	_____	_____	_____
75	_____	_____	_____
100	_____	_____	_____
125	_____	_____	_____
150	_____	_____	_____
175	_____	_____	_____
200	_____	_____	_____

b. Which option generates the greatest annual income?

c. Which option generates the greatest annual income if the amount of growth at each stock size were doubled?

d. Which option generates the greatest annual income if the interest rate were doubled to 10%? What if it were 20%?

e. Draw some general conclusions by comparing your answer in (c) to that in (b) and by comparing your answers in (d) to that in (b).

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 4

IS EXTINCTION REVERSIBLE?

Ever since the first archaeologist discovered the fossils of some unfamiliar creature, the possibility of recreating extinct species has been the subject of conjecture and debate. This debate was the subject of *Jurassic Park*, a book by Michael Crichton, which later became a Steven Spielberg movie. In this story scientists are able to bring back dinosaurs from the Jurassic period, some 70 million years ago. Is this just good science fiction or a possible answer to species preservation?

A basic requirement for such a feat is that the DNA (deoxyribonucleic acid, a basic material in the chromosomes of a cell nucleus containing the genetic code) be available. In *Jurassic Park* the DNA was found in the mandibles of insects preserved in amber — the blood cells of dinosaurs were preserved by a mosquito! Reality is not that far behind. In 1990 Edward Golenberg was able to extract the DNA from some leaves that had fallen between 17 and 20 million years ago. The leaves had been covered and sealed by mud, which had long since turned to rock, protecting them for eons. Today the U.S. Department of Agriculture supports the National Germ Plasm System (serving as modern-day "mud"!) which serves as a genetic repository for many current plant species. Seeds are carefully stored at low temperatures and humidity for use in the future.

Once a species' DNA is available, cloning technology could be used to recreate it. This technology is already rapidly advancing in the area of genetic medicine. In 1988, mice with genetically-engineered characteristics became the first life-form ever patented. In 1990, a girl with a genetic disorder of her immune system was successfully treated with gene therapy.

One can envision a massive "library" of stored genetic information where society could conceivably go and "check out" a species for re-population. An answer to the problem of species extinction or, as in the case of *Jurassic Park*, the creation of more serious problems?

CRYING "WOLF!" ABOUT RUNNING OUT OF NATURAL RESOURCES

INTRODUCTION

There is a popular children's story about a boy who, while tending the village's sheep, thinks it is funny to cry out "wolf!" and watch the villagers come running. After being fooled several times, the villagers begin to ignore the boy; and when the wolf really does come, the boy's cry of "wolf!" goes unheeded. Both the boy and the sheep are lost.

Throughout history there have been "cries" that we are running out of essential natural resources and that "the end is near" for economic development. Each time, these concerns have proved to be unwarranted. Cries of this sort are heard today about energy, many minerals, and some wildlife species. Has the "wolf" finally come, or will today's cries too sound only a false alarm?

In this lesson students discover how past resource concerns were overcome; they explore whether or not there is any reliable indicator to tell us when the "wolf" (real resource scarcity) has come. Market prices are shown to play a key role in both cases.

ECONOMIC CONCEPTS

Reserves
Potential Reserves
Reserve/Production Ratios
Price
Substitutes

ENVIRONMENTAL CONCEPTS

Resource Endowment

OBJECTIVES

- Describe the economic factors which have mitigated resource scarcity.
- Define physical measures of scarcity.
- Describe price as an economic measure of scarcity.

LESSON DESCRIPTION

Resource "scares" and concerns from the past are compared with today's concerns. Students participate in a "search" game to understand the difference between the amount of a resource which is available and current supply. Finally, those factors which have in the past mitigated the threat of resource shortages are introduced along with the role of prices.

TIME REQUIRED

One class period

MATERIALS

One copy for each student of Activities 1, 2, 3, 4, and 5
Transparencies of Activities 1, 3, and 5
Craft beads of various sizes (large, medium, small)
Tablespoon of corn meal

PROCEDURE

Prepare

1. Before class, take the beads, corn meal, etc., and toss them randomly around the room.

Crying "Wolf!"

2. Show a transparency of Activity 1. Ask: What is the general message implied by these statements? Discuss responses.

   Answers may include: we are running out of energy/natural resources; we have been "wasting" our natural resources; we are

growing beyond the environment's ability to support us.

3. Next show a transparency of Activity 2. Ask: what conclusions can you draw from this information?

   Concern about natural resource shortages is not new; these past concerns appear to have been unwarranted; something must have happened to avoid the problem.

   Remind the students of the story of the boy who cried "wolf!" (see the Introduction above) and relate it to cries about impending resource shortages.

Resource Search

4. Explain that you have thrown an unknown quantity of beads and corn meal around the room. Show the students what the beads and corn meal look like and explain the size of reach item represents a different quantity of some resource (for example, larger beads might represent 5 tons, medium 3 tons, small 1 ton, and each grain of corn meal 1/10th of a ton). Select two students whose job it is to find and collect ("extract") this resource. Give them 30 seconds to collect as much as they can. Record the "tons" collected on the board. Select two more students and repeat the process with the remaining beads and cornmeal. Finally, select another two students and repeat. Your table on the board after all three groups have searched should look something like this:

Group	Tons Collected	Total Tons Collected
1	100	100
2	50	150
3	25	175

5. Ask the following questions and discuss the responses:
   What is the supply of the resource in each period?

   The total amount collected in each period. For the table above: 100 for the first period, 50 for the second, and 25 for the third.

6. What do you notice about supply?

   The supply in each succeeding period is generally less (100>50>25).

7. Why might this be expected?

   The larger, easier-to-find beads are collected first, leaving the smaller, harder-to-find beads and the corn meal for later periods. In other words, it is more costly (in terms of the labor time needed) to collect the resource in later periods. Higher costs in turn imply less supply (see Lesson 4).

8. If the demand for the resource is the same in each period, what do you expect to happen to price over these periods?

   It should rise.

9. How much of the resource is left?

   Unknown. Uncollected beads and corn meal may still exist in some parts of the room.

How Much Do We Have Left?

10. Relate the game above to resource reserves. Ask: how much zinc or natural gas do we have left?

    Most students will respond that we have some, but it is (like the beads) running out.

11. Show a transparency of Activity 3. This activity illustrates three physical measures of "how much of a resource is left." Discuss each with respect to the "search" game in Step 4.

    Note that "Resource Endowment" is the actual amount of the resource which is physically available — it

corresponds to the actual number of beads and corn meal initially tossed around the room. "Potential Reserves" refers to the amount of the resource that could be recovered at a reasonable cost. Note that a lot of the corn meal would likely never be collected because collecting it takes too much time (i.e., is too costly). Some of the beads and cornmeal, for example, may have fallen into cracks or places that would require tearing up the walls and floor to collect! In the real world, these "beads" are represented by resources trapped in the atomic structure of other resources. The energy required to release them is so vast that it is unlikely anyone would be willing and able to pay to have it done. Thus, potential reserves is less than the total resource endowment. "Reserves" refers to the amount of the resource that can profitably be collected right now. This corresponds to the beads that could reasonably be collected during the search game. This is the most common measure used.

How many years will it be until the "wolf" comes?

12. Explain that given the measures of resource availability on Activity 3, one might be tempted to ask how long our reserves will last at current consumption or production levels. The answer is most commonly determined by taking current reserves and dividing by the current production (or consumption) level. This tells how many years our current reserves will last at current use levels, or when "the wolf" might appear at the door.
13. Distribute a copy of Activity 4 to the students. Ask them to complete the table and answer the question (figures are based on 1970 information from the U.S. Bureau of Mines). Allow 10 minutes. Discuss answers.
    a. Values for Columns 4 and 5 (note that the values in Column 4 are found by dividing those in Column 2 by Column 3, while the values in Column 5 are found by adding the value in Column 4 to "1970"):

Resource	(4) Years Until We Run Out	(5) Year When We Run Out
Copper	36	2006
Lead	26	1996
Tin	17	1987
Zinc	23	1993
Iron Ore	240	2210
Nickel	149	2119
Oil	31	2001
Natural Gas	38	2008

b. According to the information, most of these resources will be all used up around the turn of the century!

14. Next show a transparency of Activity 5. Ask: What conclusions can you draw from this? Discuss responses.
    The "years till we run out" have not changed very much, and in some cases the numbers have gone up.
15. Ask: How is this possible?
    Current reserves have increased through additional exploration (more reserves discovered), technology has lowered extraction costs (making more of the resource profitable to recover), and in some cases prices have risen (making more of the resource profitable to recover).
16. Ask: What does this say about the usefulness of "reserve/production" ratios as a measure of impending resource scarcity?
    They tend to give an overly pessimistic view.
17. Ask: What other measure might be useful to measure resource scarcity?
    Price — the economic measure of scarcity.
18. What factors would tend to cause the price of a resource to rise over time?
    Increasing scarcity (see Lesson 15), rising extraction costs as lower quality ore deposits must be mined (as exemplified by the search game above), and increasing demand for the resource.
19. What factors would tend to cause the price to fall?
    Advances in mining technology that lower the cost of extraction (note how much easier it would be to collect the beads and corn meal with a broom or vacuum!), lower demand due to conservation efforts, lower demand due to the development of substitutes for the resource.

    The faster a price is rising, the closer the wolf is likely to be to the sheep!

EXTENSION ACTIVITIES

History

20. Divide the class into small groups and assign each group to investigate the production, consumption (uses), and price of a particular mineral or fossil fuel over the past 200 years.

Math

21. The reserve/production ("years-till-we-run-out") figures determined in Activity 4 assumed that production would remain at current levels. However, production (and consumption) have generally increased over time. Assign students to determine the "year when we run out" for each resource if its rate of production (and consumption) is growing by 3%. Repeat using 8%.

    For example, zinc (reserves — 116 tons, current production — 5.04 tons):

Years from Today	Production	Cumulative Production
0	5.04	5.04
1	5.44	10.48
2	5.88	16.36
3	6.35	22.71
4	6.86	29.57
5	7.41	36.98
6	8.00	44.98
7	8.64	53.62
8	9.33	62.95
9	10.07	73.02
10	10.88	83.90
11	11.75	95.65
12	12.69	108.34
13	13.71	122.05 > 116

Values in the production column are $CP(1+r)^n$, where CP is the current production amount, r is the rate of growth, and n is the number of years from today (column 1). For example, $10.07 = 5.04(1.08)^9$. Cumulative production is determined by adding each additional year's production. We "run out" once the cumulative production exceeds the initial reserves.

Economics

22. Bring in a recent article concerning the potential shortage of landfill space in several communities, or simply mention the growing concern about running out of landfill space (many landfills close every day). Discuss with students the parallels between reserve/production figures and landfill space/annual waste generation figures. Ask: What does this lesson tell us about this impending shortage?

    It will likely be mitigated through higher prices (i.e., there will be an incentive to open new landfills as the potential shortage drives up the amount communities are willing and able to pay to dispose of their garbage. It will also be mitigated by the use of substitutes for landfilling (recycling, reusing, and reducing.

Economics/Ecology

23. The debate between some economists and ecologists over the question of running out of resources is wonderfully presented in an article by John Tierney in the December 2, 1990 edition of *The New York Times Magazine*. Assign students to read this article. It chronicles a $1000 bet between Julian Simon (an economist) and Paul Ehrlich (an ecologist), over the question of growing natural resource scarcity. Resource prices are used to settle the bet. The article is easy to read and leads to lively class discussion.

ACTIVITY 1

PREDICTIONS OF SCARCITY

1. U.S. oil supplies will last only 13 years.

2. Population growth will, if left unchecked, eventually outstrip the growth of food supply, leading to massive famine.

3. At current consumption rates the world's reserves of copper will be exhausted in only 36 years, zinc in 23 years, and mercury in 13 years.

4. The rapid increase in coal consumption coupled with the finite nature of its supply will cause economic progress to stop in the near future.

5. The expected life of the Mesabi range of northern Minnesota as a source of iron ore is five to seven years.

6. The Nation is in the position of a man, who, bequeathed a fortune, has gone on spending it recklessly, never taking the trouble to ask the amount of his inheritance, or how long it is likely to last.

ACTIVITY 2

RESOURCE REALITIES

1. Source: 1939 radio broadcasts by the U.S. Interior Department.

   Reality: New oil found since 1939 exceeds the total reserves known to exist at that time.

2. Source: Principal message of Thomas Malthus' *A Summary View of the Principle of Population*, 1830.

   Reality: The "Green Revolution" (technological advances in farming techniques and hybrid crops) has led to agricultural surpluses. Population growth in developed countries has dramatically slowed.

3. Source: Based on information in U.S. Bureau of Mines, *Mineral Facts and Problems*, 1970.

   Reality: By 1990 these numbers were still about the same! (that is, we still had 17 years of tin left even though all the reserves should have been exhausted by 1987, according to the 1970 figures!).

4. Source: Summary of the conclusion of Stanley Jevon's *The Coal Question: An Inquiry Concerning the Progress of the Nation and the Probable Exhaustion of Coal Mines*, 1865.

   Reality: Britain still depends on its coal reserves for a significant amount of its energy.

5. Source: Comment of C. M. White, President of Republic Steel, 1947.

   Reality: Discovery of a new technique to process iron ore (pelletization) has kept mines open to this day.

6. Source: National Conservation Commission, 1908.

   Reality: Natural resource prices have historically fallen, indicating that the question of them running out may not yet be relevant.

*From **Economics and the Environment**; ©National Council on Economic Education, New York, NY*

ACTIVITY 3

PHYSICAL MEASURES OF RESOURCE AVAILABILITY

RESOURCE ENDOWMENT

The total amount of a resource that is physically present in the earth's crust. This represents the physical limit of a resource's availability.

POTENTIAL RESERVES

The total amount of a resource that could be economically recovered, now or in the future. This represents the economic limit of a resource's availability.

RESERVES

The total amount of a resource that could profitably be recovered at current prices using current technologies. This is the most commonly used physical measure of resource availability.

ACTIVITY 4

HOW LONG WILL IT BE UNTIL THE "WOLF" COMES?

The table below shows the amount of reserves (Column 2) of various resources in 1970. Column 3 shows the amount of each resource that was used in 1970.

a. Complete the table. (Round values in Column 4 to the nearest whole year.)
b. What conclusions can you draw from this table about impending shortages of these resources?

(1) RESOURCE	(2) 1970 RESERVES*	(3) 1970 CONSUMPTION*	(4) [(2)/(3)] YEARS TILL WE RUN OUT	(5) [1970+(4)] YEAR WHEN WE RUN OUT
COPPER	278	7.72	_____	_____
LEAD	83	3.19	_____	_____
TIN	4.4	0.26	_____	_____
ZINC	116	5.04	_____	_____
IRON ORE	91,000	379.17	_____	_____
NICKEL	67	0.45	_____	_____
OIL	455 bbls.	14.68 bbls.	_____	_____
NATURAL GAS	1.14 tcf.	0.03 tcf.	_____	_____

*Figures for minerals are in millions of metric tons (one metric ton = 2,205 pounds).
For oil, bbls. = billions of barrels.
For natural gas, tcf. = trillions of cubic feet).

Source: U.S. Bureau of Mines, *Mineral Facts and Problems*, 1970.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 5

THOSE RESILIENT RESERVES

Resource	1990 Reserves*	Years Until We Run Out
Copper	321	36
Lead	70	21
Tin	5.92	27
Zinc	144	20
Iron Ore	151,000	175
Nickel	49	52
Oil	895 bbls.	40
Natural Gas	3.86 tcf.	60

*Figures for minerals are in millions of metric tons (one metric ton = 2,205 pounds). For oil, bbls. = billions of barrels. For natural gas, tcf. = trillions of cubic feet).

Source: U.S. Bureau of Mines, *Minerals Yearbook*, 1990.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

UNIT 7

ECONOMIC DEVELOPMENT IN A FINITE ENVIRONMENT

RECYCLING: A TALE OF TWO MARKETS

INTRODUCTION

It is the best of things, it can be the worst of things. Recycling is often regarded as a win-win environmental solution. Not only does recycling reduce the flow of wastes to landfills and incinerators; it also helps conserve virgin natural resources. But like any economic activity recycling also involves costs — scarce resources are used in the process. In this lesson students look at the two markets (collection and reprocessing) through which recyclable materials pass; they learn how costs are reflected, and why too much of a good thing can sometimes be a bad thing.

ECONOMIC CONCEPTS

Costs
Change in Demand
Change in Supply
Derived Demand
Equilibrium
Price
Market

ENVIRONMENTAL CONCEPTS

Recycling

OBJECTIVES

- Describe the benefits of recycling.
- Explain the flow of recyclable materials through markets.
- Analyze supply and demand changes in the collection and reprocessing markets for recyclables.
- Describe the costs associated with recycling.
- Explain why different materials are recycled at different rates.

LESSON DESCRIPTION

The collection and reprocessing markets for recyclables are described. Students analyze the workings of these markets. Some of the costs of recycling are demonstrated by an activity in which students actually produce some recycled paper.

TIME REQUIRED

Two class periods

MATERIALS

One copy for each student of Activities 1, 2, 3, 4, and 5
Transparencies of Activities 4 and 5
To make recycled paper:
Newspapers
Bucket
Water
Cornstarch
Wire Whisk
Pieces of screen (6" x 6")
Rolling Pin
Sheets of plastic wrap to cover the screens

PROCEDURE

The Recycling Process

1. Ask: What are the benefits of recycling? Discuss responses.
   Most students already know. Two principal benefits are (1) recycling leads to a reduction of waste flows into landfills and incinerators, and (2) it allows us to conserve some of our virgin natural resources. Students may also add that it saves energy in that processing recycled materials in some cases takes less energy than extracting virgin materials.
2. Ask: Given these benefits, should society's goal be to recycle 100% of all natural resources used? Discuss responses.

Probably not. Students should realize that recycling also involves costs. It is generally more efficient to recycle those materials which are easier (and less expensive) to reprocess at higher rates. To drive this point home, have students consider the difference in costs between trying to recycle aluminum cans and toilet paper.

3. **The amount of recycling of a given material is determined in the recycling markets. To help students understand how these markets work ask: How do recycled materials get from the original users (often consumers) back into the production sector? Discuss responses.**

   The original users must first separate recyclable materials out of their waste flows. These materials are collected or taken to recycling centers. From there they are sent to processing centers which convert them into useable materials for sale to producers. Note that this sets up two basic markets: the market where recyclable materials are exchanged between consumers and the processors (the "collection" market) and the market where the processed recyclables are exchanged between the processors and the producers (the "reprocessing" market).

The Collection Market

4. **Ask: How are recyclables collected in our area?**

   Answers will vary. Many cities now have compulsory recycling of many materials at the curbside. Others rely on voluntary systems and/or recycling drop-off centers.

5. **If possible, invite representatives from a local recycling collection/processing center speak to the class about their operation and the prices they offer for various materials. If this is not possible, call such a center before class and collect some price information on the various materials it accepts (newspapers, aluminum, plastics, various colors of glass, tin, and others). Report these prices to the class.**

   While some prices are likely to be positive, others will likely be zero, or even negative (you have to pay the center to take them).

6. **Ask: What determines these prices and why are they different?**

   Supply and demand.

7. **Ask: Who are the suppliers and who are the demanders in the collection market?**

   Suppliers: original users of the materials (consumers and producers); Demanders: reprocessing centers which process the materials into useable resources which they can sell to producers. Note that the demand for recyclable material by processors is a "derived demand" based on the demand for reprocessed resources by producers.

8. **Ask students working individually to draw three sets of demand and supply curves: one which yields a positive price, another a price of zero, and one where the price is actually negative. Allow five minutes.**

9. **Distribute Activity 1, which illustrates these cases. Focusing on the "negative" price market, ask: Why would people pay to drop off their recyclables?**

They could simply receive satisfaction from doing what many consider to be the right thing. This sense of satisfaction may constitute a benefit exceeding the costs they incur to separate, store, and transport their recyclables. They may also have another economic reason: it may be more costly (or even illegal, given recycling mandates) to have such items hauled away as garbage. Also, as the costs of disposing of garbage have increased, some cities have started to price garbage services according to how much people put out for disposal. Thus, by recycling, people could save on their garbage bill.

10. **Distribute a copy of Activity 2 to each student and assign students working in groups of two to complete it. Allow 10 minutes and then discuss their answers.**

Change	Reason	Price	Amount Collected
a. S increases	other option lost	falls	rises
b. D increases	more derived demand	rises	rises
c. S increases	reduce garbage bill	falls	rises
d. no effect	choice unaffected	remains	remains
e. S increases	incentive to return	falls	rises
f. D decreases	less derived demand	falls	falls
g. S decreases	less time devoted to separation	rises	falls

The Reprocessing Market: Making Paper

11. **Ask: Who are the buyers and sellers in the reprocessing market?**
    The processors of recycled materials are the sellers while producers desiring reprocessed resources are the demanders.
12. **Ask: What costs are associated with processing recyclable materials?**
    Resources (including energy) required to collect, transport, process, and store materials, plus payments for the recyclables (if positive — remember the collection market!).
13. **These costs can be demonstrated most vividly by having the students actually process newspapers into recycled paper. Show them how it is done:**
    a. **Tear newspaper into small pieces (the smaller, the better).**
    b. **Place pieces into a bucket until it is half full (use several buckets if you wish to involve the whole class).**
    c. **Add water to soak the pieces.**
    d. **Let the mixture stand over night.**
    e. **Use wire whisk to beat the mixture into a pulp.**
    f. **Dissolve three tablespoons of cornstarch in one cup of water and stir into the mixture.**
    g. **Dip screens in the pulp and pull out. Repeat until the screen is covered with about a 1/8th-inch layer.**
    h. **Place screens on spread-out newspapers (pulp side up).**
    i. **Cover the screens with plastic wrap.**
    j. **Use rolling pin to press out the water.**

k. Prop up the screens and allow them to dry.
l. When dry, gently peel off sheet of recycled paper

14. What costs were involved in this process?

Many resources (which — you should point out — have valuable alternative uses) were used: capital (buckets, whisk, rolling pin, screens), human (the students and teacher), and natural (water and cornstarch). Also there would be the time and effort expended in collecting the newspapers in the first place.

15. How are these costs reflected by the supply of recycled paper?

Suppliers are willing and able to supply this paper only if the amount they receive is greater than the costs of producing it.

16. What might affect the demand for the paper you produced?

Since this paper is a substitute for paper produced from virgin timber, the price of the latter will influence the demand. Also, since recycled materials (here paper) may be of different quality than that produced from virgin sources, the quality of the recycled paper will be important.

Changes in the Reprocessing Market

17. Distribute a copy of Activity 3 to each student and once again have students working in groups of two complete it. Allow 10 minutes and then discuss students' answers. (See table below.)

Remind students that supply is merely a reflection of the costs incurred by the seller, while demand is a reflection of the value received by the buyer (see Lessons 3 and 4).

18. Close out the discussion in this section by noting that the market conditions for various materials are different and that this explains not only why there are different prices for recycled materials, but also different rates of recycling (the percent of virgin material which is recycled). Show a transparency of Activity 5.

Change	Reason	Price	Amount Recycled
a. S increases	lower transportation costs	falls	rises
b. D increases	price of substitute higher	rises	rises
c. D decreases	price of substitute lower	falls	falls
d. S increases	lower production costs	falls	rises
e. D increases	price of substitute higher	rises	rises
f. S decreases	higher input costs	rises	falls

Ask students how the recycling rate is likely to be affected in each case shown — assuming everything else is the same (particularly demand for the reprocessed resource).

Collection Costs	Reprocessing Costs	Recycling Rate
High	High	Low
High	Low	Medium
Low	High	Medium
Low	Low	High

Aluminum provides a likely example of a material in the "low-low" category. Paper, glass, and plastics would probably fall in the "low-high" category. Wood products (furniture, demolition materials, etc.) would likely fall in the "high-high" category.

19. Explain that some materials are better candidates for recycling than others because their collection and/or processing costs are low with respect to the costs of acquiring virgin materials. For other materials it may be best not to recycle, since recycling would be more costly (remember the resources required) than simply using virgin materials. Have students draw what the demand and supply curves in the reprocessing market would look like in this latter case (where the market produces no recycled materials). Allow five minutes and then show a transparency of Activity 5. Discuss the transparency.

    The cost of reprocessing the material (reflected by the supply curve) is always greater than what producers are willing and able to pay for the recycled material (because, for example, the price of the virgin substitute is less).

EXTENSION ACTIVITIES

Math/Economics

10. Pose the following question to students: If a nonrenewable resource can consistently be recycled at a 50% rate, how much does this recycling increase the amount of the resource which is available?

    It doubles the amount available. The formula for this is one that may be familiar to many economics students: 1/(1-r) where r is the rate of recycling. In this case 1/(1-.50) = 1/0.50 = 2.

21. Write this formula on the board and if possible have students compare it to the income multiplier from macroeconomics: 1/(1-MPC) where MPC is the marginal propensity to consume, or the percent of income that is spent on consumption expenditures.

    Note that both formulas are based on finding the sum of an infinite series. For example, if one started with 100 units of a resource and recycled at a rate of 50% (as the case above), then the total amount available would be:
    100 + 50 + 25 + 12.5 + 6.25 + 3.125 + . . . = 200.

    Similarly, if there is a $100 increase in the economy's income and the MPC is 50%, the total amount of income generated would eventually be $200.

22. Assign students to use the formula above to determine how much larger the available resource stock would be at each of the following recycling rates: 10%, 25%, 40%, 75%, and 90%. Answers follow.

    For 25%: S = 1/(1-.25) = 1/(.75) = 1.33 so, 1.33 times larger. Similarly, for 40% — 1.67 times larger; for 75% — 4 times larger, and for 90% — 10 times larger. The point is that recycling does not extend the useful life of a nonrenewable resource by as much as many think — even if it is recycled at a rate above 50%, which few resources are.

Geography/Economics

23. In the late 1980s the United States handled most of its solid wastes by landfilling (80%), with the remainder either being incinerated (10%) or recycled (10%). At the same time

Japan was reporting the following percentages: landfilling 16%, incineration 34%, and recycling 50%. What geographic factors might explain this vast difference in how solid wastes were handled in the two countries?

Two geographic features are noteworthy. First, the land area of Japan is 144,000 square miles, compared to 3,618,770 square miles for the United States. Thus, while the population of the United States is twice that of Japan, its available land is more than 25 times that of Japan. Since land is relatively less scarce in the United States it is not surprising that it is used in more "low-valued" ways (e.g., for waste disposal).

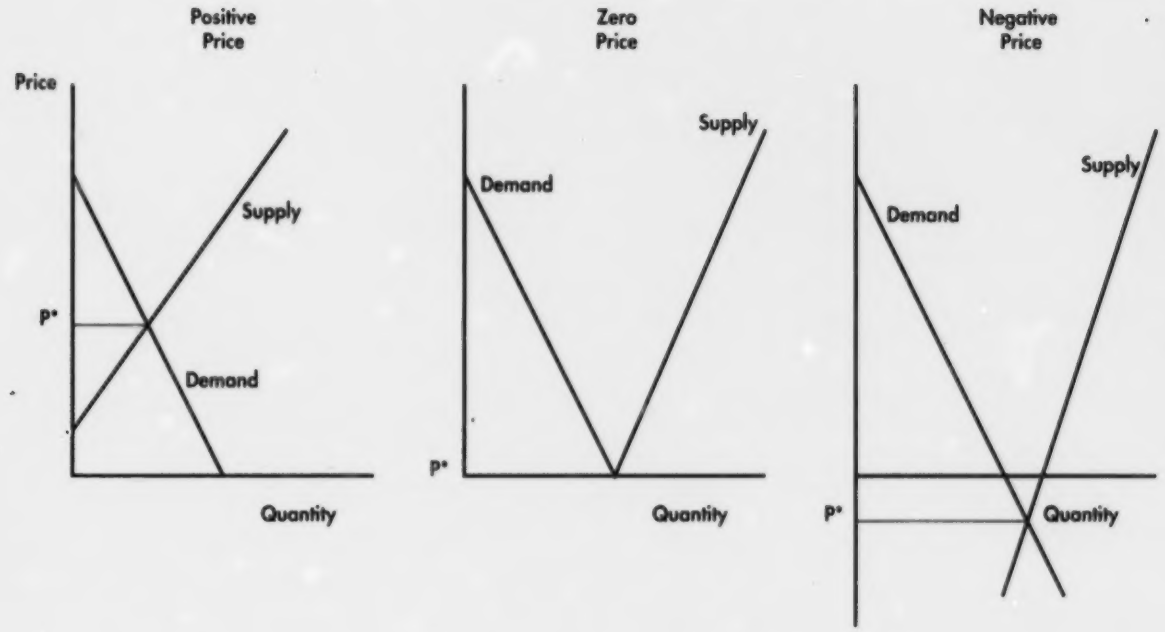
A second feature (related to the first) is Japan's relative lack of natural resources, including energy resources. Japan must import many raw materials (cotton, wheat, iron ore, rubber) and energy resources (coal and oil). Thus, recycling provides an important source of raw materials (that may be less costly than imports). Similarly, incineration provides an alternative energy source to fossil fuel imports. In the United States, virgin raw materials and energy resources are relatively more abundant (and less costly); thus the demand for recycled materials and the need for waste-produced energy are less.

Community

24. If your community has a firm that processes recyclable materials (i.e., does more than merely collect them), arrange for a speaker from the firm to visit your class, or arrange for a tour of the firm. Assign students to prepare questions related to the "processed recyclables" market. In particular, they should ask about the process itself (resources used, costs, etc.) and what is done with the final product (who buys it, and what do buyers do with the recycled materials?).

ACTIVITY 1

POSITIVE, ZERO, AND NEGATIVE PRICES

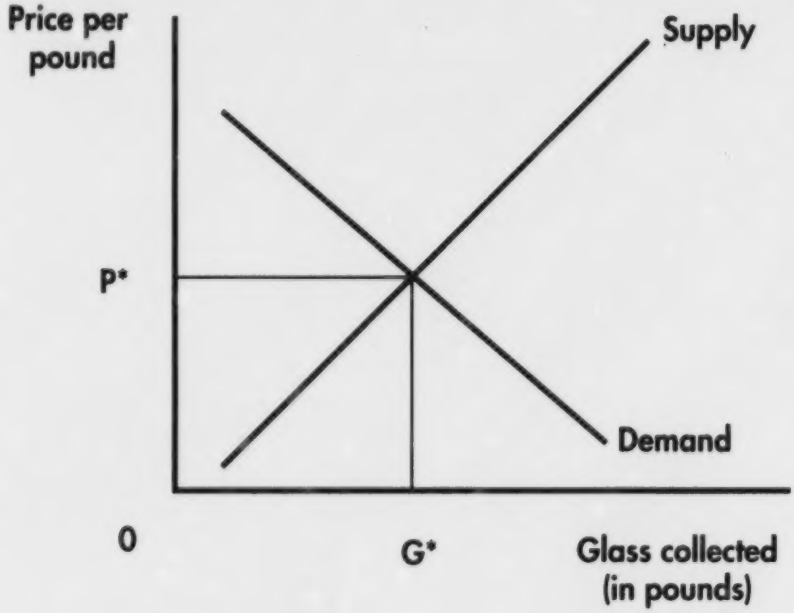


From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

THE COLLECTION MARKET

Pictured below is the collection market for glass. As is the case in any market, the demand and supply conditions here are constantly changing. Below are several changes. For each, determine which curve would be affected and how each change would affect the equilibrium price and amount collected.



a. The state legislature passes a law that forbids the placement of glass materials in regular garbage collection.

b. Consumers increase their demand for products made out of recycled materials.

c. Garbage rates (based on the amount collected) rise.

d. Garbage rates (based on the amount collected) rise.

e. The state legislature passes a "bottle bill" that requires individuals to pay a deposit on glass beverage containers (the deposit is refunded when the container is returned to the store).

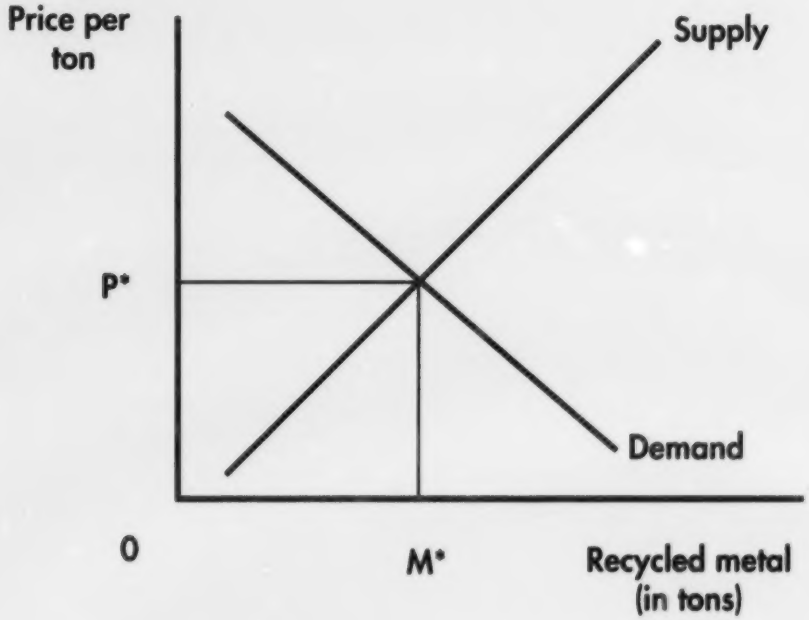
f. The price of producing glass from sand and silicates falls as energy prices fall.

g. People's demand for spending their time in recreational activities increases.

ACTIVITY 3

THE REPROCESSING MARKET

Pictured below is the market for a recycled metal. As is the case in any market, the demand and supply conditions here are constantly changing. Below are some changes. For each, determine which curve is affected and how the change would affect the equilibrium price and quantity of the recycled metal purchased.



a. Federally-regulated shipping rates on scrap metals are lowered to equal those used for virgin ores.

b. Tax subsidies (particularly depletion allowances) for industries extracting natural resources are eliminated.

c. Technological advances reduce the cost of extracting the ore containing this metal.

d. Technological advances reduce the cost of separating this metal out from other materials.

e. Firms extracting the virgin ore must start paying the cost of any environmental damage (erosion, loss of aesthetics, habitat loss, etc.) they may be causing.

f. The price paid for this metal in the collection market rises.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

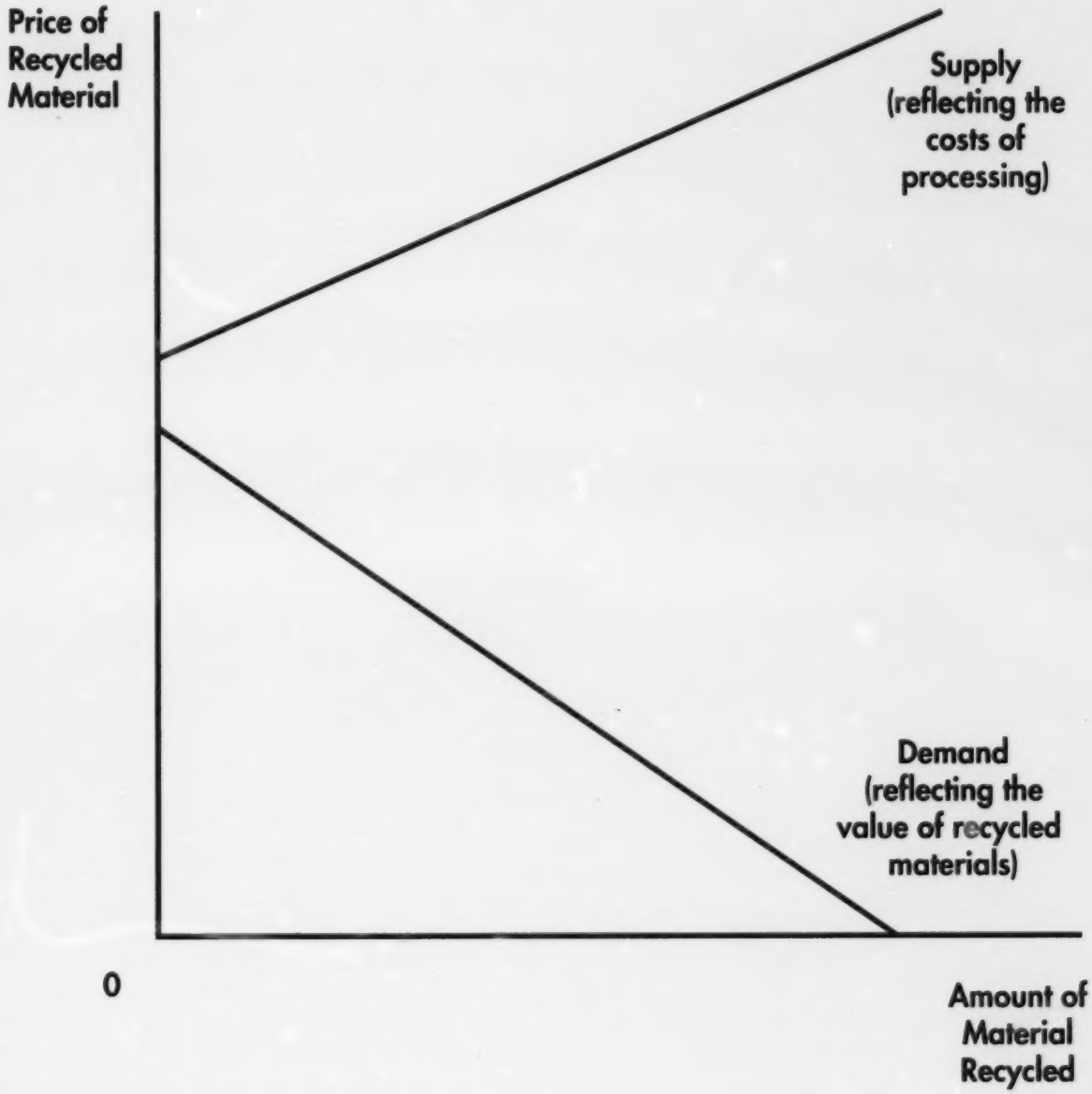
ACTIVITY 4

COSTS AND THE RECYCLING RATE

		Reprocessing Costs	
	Collection Costs	HIGH	LOW
	HIGH		
	LOW		

ACTIVITY 5

WHEN THE COSTS OF RECYCLING EXCEED THE BENEFITS RECEIVED


Price of Recycled Material
Supply (reflecting the costs of processing)
Demand (reflecting the value of recycled materials)
0
Amount of Material Recycled

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

HOW MANY CHILDREN CAN MOTHER EARTH STAND?

INTRODUCTION

With the world's population doubling every 41 years, merely to maintain everyone's current flow of goods and services would require that we double the quantity of these goods and services produced every 41 years. And while advances in technology may allow us to supply these goods and services without doubling our use of resources, it still boggles the mind to figure out where all these people are going to live — space is limited! In this lesson students look at population growth, its impact on economic development, and the economic aspects of choosing to have children.

ECONOMIC CONCEPTS

Economic Development
Economic Growth
Diminishing Returns
Technology
Productivity

ENVIRONMENTAL CONCEPTS

"Rule of 70"
Total Fertility Rate
Population Growth
Zero Population Growth (ZPG)

OBJECTIVES

- Describe recent trends in population growth.
- Discuss the number of children a couple has as an economic choice.
- Explain the effect of population growth and other factors on economic development.

LESSON DESCRIPTION

Population statistics are introduced to students, presenting examples students can relate to their own lives (living space and family size). The effect of economic development on population growth is illustrated as students consider the benefits and costs of having children. A production simulation demonstrates the role of diminishing returns and technology to help illustrate the effect of population growth on economic development.

TIME REQUIRED

Two class periods:
Day 1: Steps 1-17
Day 2: Steps 18-26 plus any Extension Activities

MATERIALS

One copy for each student of Activities 1, 2, and 3 (plus Activity 4E)
Four sets (each set different in a color from the other sets) of 50 sheets of paper
A fully-loaded stapler

PROCEDURE

Some Population Statistics

1. Ask the class: What approximately is the world's population?
   Around six billion people by the turn of the century.
2. To give students an idea of the space required to support this many people, ask them to determine how much space each person could occupy if the entire world's population had to be contained in their state. Provide them with information on your state's area (available in most dictionaries). Here is a sample calculation:
   Taking our smallest state, Rhode Island, each person would get 5.64 square feet or a little less than a 2 foot x 3 foot area — standing room

only. The calculation: Rhode Island has an area of 1214 square miles. There are 27,878,400 square feet (5280 x 5280) in a square mile. So, dividing the state's total square footage 33,844,377,600 (1214 x 27,878,400) by 6 billion yields 5.64 square feet. If this is done for Texas, each person would have 1242 square feet — a space the size of a small home. A family of four would get almost 5000 square feet or a space roughly the size of an average city lot (50 x 100 feet). Thus, there is arguably enough room in Texas for everyone in the world to live, but how much extra space would be required for factories, stores, airports, roads, hospitals, schools, farms to feed these people, and wilderness areas?

3. Distribute a copy of Activity 1 to each student. Give the students five minutes to plot the information shown in the first six lines of the table (from 1 AD to 2000) on the first time line. Ask them to describe the shape of this curve. It will be fairly flat at first; then it will bend sharply towards the end.
4. Ask the students to draw conclusions based on this curve. Discuss responses.

   Many will say that population growth is "out of control" or that the "end is near"—a population collapse (famine) due to a general lack of resources is inevitable. Tell them to hold this thought for a moment as you investigate population statistics further.
5. Ask: If the world's population continues growing at its current rate of 1.7%, how long will it take before the population doubles?

   Let students take some guesses. The answer is about 41 years.
6. Note that the "years required to double" can be estimated with the "Rule of 70": simply divide 70 by the growth rate expressed in whole numbers. For example, given a growth rate of 1.7%, the time it takes for the population to double is 70/1.7 = 41 years!
7. Assuming that the world's population continues to grow at a rate of 1.7% from the year 2000 on, direct students to complete the table on Activity 1, showing the year in which the world's population would reach 12 billion, 24 billion, and 48 billion. Answers follow.

   Since doubling would occur every 41 years: 2041, 2082, and 2123 respectively.
8. Now have students plot the information in this table again, including these new figures on the second time-line on Activity 1. Ask them for any conclusions they can draw from looking at this and comparing it to the previous time line. Discuss responses as follows.

   Now population doesn't appear to "take off" until the latter half of the 21st century! The lesson is that one must be careful with graphs like these because they may be used to give whatever impression one wants. The real determinant of whether or not the population is "out of control" is how close it is to the capacity of the earth's resources to sustain it and whether or not its growth will slow or stop before reaching that point (see Lesson 20).
9. Next distribute Activity 2 and its accompanying worksheet to each student. This activity will serve as a reference for the remainder of the lesson. Assign students to complete

the worksheet as homework for the following class period. Answers follow.

a. Africa (3.0), Mexico (2.2), India (2.1), South America (2.0)
b. Italy (0.0), Sweden and Britain (0.2), Europe (0.3), Japan (0.4)
c. At 0.8, the growth rate of the U.S. population is greater than that of Europe (0.3), less than that of the world (1.7), and much less than that of Mexico (2.2)
d. 70/0.8 = 87.5 years for the United States
70/3.0 = 23.3 years for Africa
70/0.3 = 233.3 years for Europe
70/0.4 = 175 years for Japan
70/2.2 = 31.8 years for Mexico
70/1.4 = 50 years for China
e. The more developed regions (U.S., Europe, Japan) have lower population growth rates than do the less developed regions (Africa, South America, India). It might also be noted that those regions with the highest growth rates are also those with the largest share of the world's current population (this explains why the world growth figure of 1.7% is closer to that of the less developed regions than that of the more developed regions.)

10. Note the following trend before leaving this section on population growth: For every region listed on Activity 2 except for Africa, annual growth rates have been going down since the 1970s after having increased throughout most of human history up until that time. World population is predicted to grow by 1.6% in the late 1990s (down from the current 1.7%).

Choosing Your Family Size

11. Ask each student to write down an answer to each of the following three questions:
    a. How many children do you want in your future family?
    b. Give at least one reason why you don't want more children than you stated (a).
    c. If the number you stated in (a) was not zero, give at least one reason why you don't want fewer children.
12. Tally the results from (a) on the board (number of students stating "0", "1", "2", etc.) and find the class average. Compare this to the Total Fertility Rate (TFR) figures shown in Column 2 of Activity 2. Note that the TFR shows the number of children an average woman (or couple) is expected to have in her lifetime. Next compare the class average (and the figures in Activity 2) to the "replacement level" of TFR: 2.11. This represents the number of children an average woman (or couple) must have during her lifetime to exactly replace herself and her husband (the extra .11 of a child is required to account for those women who do not survive until their childbearing years and because slightly more than 50% of births are male).

    Note that the TFRs of Europe, Australia, Japan, Canada, and the U.S. are all below 2.11.
13. Regions with a TFR below this level will eventually (over a generation or two) see their population stabilize (ZPG — zero-percent population growth) and then fall.

    Like any choice, the choice of how many children to have involves a typical economic problem of considering benefits and costs. Ask students to report their responses for

(c) and write these on the board — they represent the benefits. Discuss responses.

Most answers will likely involve some variation of (a) below. To elicit others, ask students why people in less developed countries might voluntarily choose to have children.

a. direct parental satisfaction based on love, friendship, being able to relive youth through your children, etc.
b. increase family resources to generate greater income.
c. provide for old-age security.
d. for social status.
e. fulfill a religious belief.
f. fulfill a custom of the culture.

14. Next have students report their answers to (b). These will represent the costs.

Discuss responses.

a. Direct expenses for food, clothing, shelter, education, medical care.

b. Opportunity cost of the parents' time (i.e., interferes with careers or other pursuits).

15. Distribute Activity 3 to each student. These benefits ("demand" for children) and costs ("supply" of children) can be represented as shown. People will choose to have additional children as long as the additional benefit of another child exceeds the additional cost. Ask: How many children would the person whose benefits and costs are shown choose to have?

Two. The last "whole" amount of children where the additional benefits exceed the additional costs.

16. Assign students to complete the rest of the activity. Allow 10-15 minutes and then discuss their answers in class. Answers follow.

a. Benefits; Down; Less (less able to use children to generate family income)
b. Benefits; Down; Less (less need to rely on children for support)
c. Costs; Up; Less (higher education costs/taxes; children unavailable to generate income)
d. Costs; Up; Less (opportunity cost of women's time in childcare/parenting is higher)
e. Benefits; Down; Less (fewer children are needed to insure that some will survive to provide benefits desired)

17. Note that all these changes tend to lead to a decrease in the desired number of children. Conclude by noting that in general it appears that economic development (defined below) tends to reduce the number of children desired and thus leads to slower population growth.

The Effect of Population Growth and Other Factors on Economic Development

18. Define *economic growth* and *economic development.*

Economic growth refers to increases in the economy's *total* output of goods and services; *economic development* refers to increases in *per capita* output. Keep in mind that while goods and services in general also include those products provided by the environment, these are not usually counted in official statistics — see Lessons 1 and 2.

19. Tell the students that they are going to investigate the effect of population

growth on a country's economic development. Write the following simple equation on the board: "Q = L x A." Define Q as the economy's total Quantity of output (goods and services produced by the economy), L as the size of its Labor force, and A as the output per laborer (that is, a worker's Average productivity). To get an expression for per capita output, next divide each side by P, the country's Population. Write the following: "Q/P = L/P x A." Thus, per capita output (Q/P) depends upon (1) the percent of the population in the labor force or the labor participation rate (L/P), and (2) the average productivity of laborers or output per worker (A). Lead the class in an investigation of how population changes each of these.

20. For the first factor have students compare the growth rate of the population (Column 1 on Activity 2) to the growth rate of the labor force (Column 3 on Activity 2) for Africa. Ask: What can you conclude about what will happen to the labor participation rate over time? Discuss responses as follows.

    Since L (the labor force) is growing slower (2.6% versus 3.0%) than P (the population), L/P (the labor participation rate) would be falling over time — having a negative effect on economic development. If L is growing faster than P (in all regions shown except for Africa, India, and the former Soviet Union), then L/P would be rising — having a positive effect. Note that for the world as a whole L/P is falling.

21. The labor participation rate for the United States is around 0.5 (about half the population is in the labor force). Ask: What factors might cause this to go up or down in a country? Discuss two possibilities:

    a. The age distribution of a country. Most of the labor force of a country is composed of people between the ages of 15 and 65, so L/P changes as population moves in and out of this age class. For example, an abundance of youths in a rapidly growing population would tend to reduce the labor participation rate.

    b. The availability of employment opportunities.

22. To demonstrate the effect of population changes on the second factor (A, the average productivity of laborers, or output per worker), conduct the following production simulation: Ask two student volunteers to come to the front of the class. They are going to produce packets of colored paper. Each packet is to contain four sheets of paper; each sheet in the pack must be of a different color; and the sheets must follow a specific order (for example, green first, blue second, etc.).

    Have them work on different desks and limit the space in which they are allowed to work (space is going to be a fixed input in the simulation). Two techniques will be used. For Technique X, set out four separate piles of paper (already sorted by color) plus a stapler to form the packet. For Technique Y, set out one pile of paper with the colors randomly mixed.

    To hold the packet together, one corner must be folded down and a "tab" torn out. Tell each student that he or she is to produce as many packets as possible from when you

say "go" to when you say "stop." Note that only packets meeting reasonable quality standards will be counted. Say "go" and allow students to produce for about 30 seconds. Record the results on the board (see below).

23. Now direct two more students to come up to add to the labor force of each factory. You can suggest that the augmented teams might specialize their tasks (one collates, one connects). Again allow about 30 seconds for production, and record the results when each factory has two workers. Continue bringing students into the factories one at a time (forcing them to stay in a confined space in front of each desk). Typically no more than four will be necessary to demonstrate the inevitable diminishing returns. When the simulation is over you should have a table on the board that looks something like this:

Number of Workers	Packets Produced with Technique X	Packets Produced with Technique Y
1	6(6)	4(4)
2	10(5)	6(3)
3	12(4)	7(2.3)
4	13(3.25)	8(2)

24. Ask students to calculate the output per worker (A) for each technique at each employment level (output divided by number of workers — shown in parentheses in the table above).
25. Ask students to draw conclusions about the output per worker based on this table.

    Discuss these possibilities:

    a. Comparing output per worker within one technique: while output increases as the number of workers increases, average productivity tends to fall (due to diminishing returns with fixed space — land). Thus, a doubling of the labor force doesn't imply a doubling of output. The implication: given the limitations of a finite environment, output per worker will tend to fall as population (and the labor force) grow.

    b. Comparing output per worker across techniques: Improvements in the way things are done plus increased use of capital (the stapler) can increase output per worker. The implication: technological advances over time plus the increased use of capital can offset the effect of diminishing productivity. It might be noted that some economists have suggested that human ingenuity to find these "better ways" is a resource that is enhanced by having more people (greater population).

26. Note that since the labor participation rate (L/P) and worker productivity (A) can each go up or down over time, the effect of population growth on economic development depends on which of the factors described above is dominant. Close by asking for student opinion on the relative strength of these factors in the future.

EXTENSION ACTIVITIES

Economics

27. The relationship between population and economic development is not a new topic. Assign students to investigate the writings of Thomas Malthus (1766-1834). His work gave economics the label "the dismal science." It also prompted someone to coin the adjective "Malthusian," which is used to signify dire or gloomy consequences. Malthus predicted that population will tend to increase faster than food supply, so that famine and disease will keep mankind basically at the subsistence level. Ask students to discuss why his predictions have not come to pass and whether or not they still might.

Government

28. Assign students to investigate how various governments around the world try to influence the population growth of their country. China and India are good examples. Students might also investigate the effect international organizations (such as the United Nation's World Health Organization) have had on population growth in terms of reducing death rates.

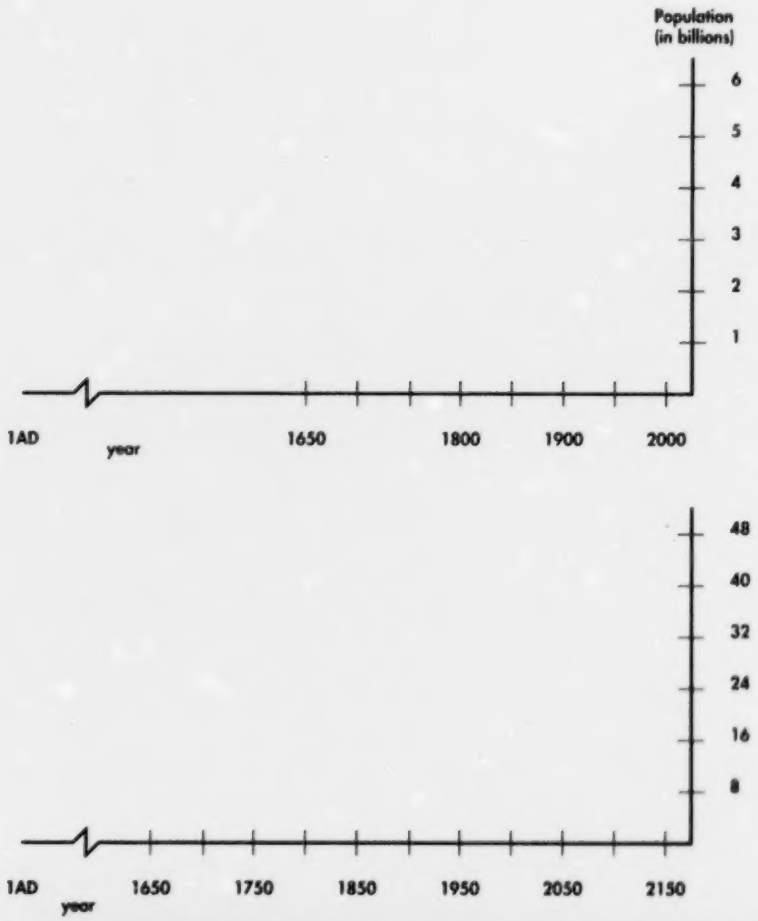
Math

29. Distribute a copy of Activity 4E to each student. Allow 10-15 minutes and then discuss the students' answers as follows.
    i. arithmetic: 7, 10, 13, 16, 19, 22, ... geometric: 7, 21, 63, 189, 567, ...
    ii. a. 100 (today), 110 (in 10 years), 120 (in 20 years), ... , 190 (in 90 years), and 200 (in 100 years)
    b. 2 (today, in thousands), 4 (in 10 years), 8 (in 20 years), 16 (in 30 years), 32 (in 40 years), 64 (in 50 years), 128 (in 60 years), 256 (in 70 years), 512 (in 80 years), 1024 (in 90 years), 2048 (in 100 years)
    c. (a) is arithmetic (adding 10 each decade); (b) is geometric (multiplying by two each decade)
    d. At 60 years agricultural production is 160 units while population is at 128 thousand, but by the 70th year agricultural production (170 units) is less than the amount required to feed the population (256 thousand).

ACTIVITY 1

WORLD POPULATION GROWTH

Date	*Population*
1 AD	0.25 billion
1650	0.50 billion
1850	1.00 billion
1930	2.00 billion
1975	4.00 billion
2000	6.00 billion
____	12.00 billion
____	24.00 billion
____	48.00 billion



From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

SELECTED REGIONAL DATA

	(1) Growth Rate of Population*	(2) Total Fertility Rate#	(3) Growth Rate of Labor Force @
Africa	3.0%	6.0	2.6%
North & Central America	1.3	2.4	1.4
United States	0.8	1.9	0.9
Canada	0.9	1.7	1.0
Mexico	2.2	3.1	3.2
South America	2.0	3.2	2.2
Asia	1.9	3.3	2.0
Japan	0.4	1.7	0.8
China	1.4	2.3	1.9
India	2.1	4.1	2.0
Oceania	1.5	2.4	1.6
Australia	1.4	1.8	1.6
Soviet Union (former)	0.8	2.3	0.5
Europe	0.3	1.7	0.5
Britain	0.2	1.8	0.2
Italy	0.0	1.4	0.5
Sweden	0.2	1.9	0.4
World	1.7	3.3	1.8

*Average annual growth rate over the period 1985-90

#Number of children an average woman is expected to have during her lifetime (period: 1990-95)

@Average annual growth rate over the period 1985-90
Source: *World Resources*, The World Resources Institute, Oxford (1992)

ACTIVITY 2

ANALYZING POPULATION DATA

Use the information in Column 1 of Activity 2 to answer the questions below:

a. Which regions and countries listed have the highest growth rates of population?

b. Which regions and countries listed have the lowest growth rates of population?

c. How does the growth rate of the U.S. population compare with that of Europe? ...the world? ...Mexico?

d. The "Rule of 70" can be used to estimate the number of years it takes for a region's population to double:

Doubling time (in years) = 70/(Growth rate)

where the "Growth rate" is expressed in whole numbers. For example, the world's growth rate is 1.7%, so the world's population will double in about 70/1.7 = 41 years. Given this, estimate the number of years it will take for the population of the following to double if their growth rates continue to be the same:

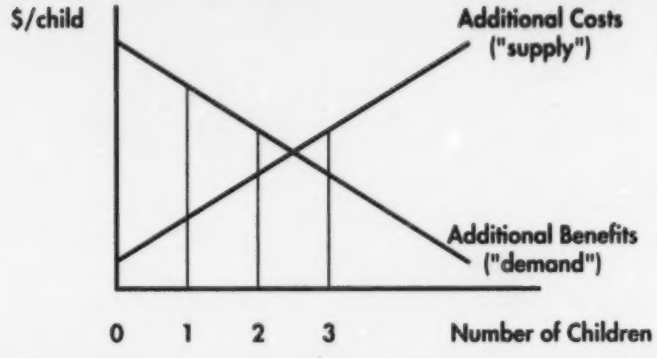
_____ United States
_____ Africa
_____ Europe
_____ Japan
_____ Mexico
_____ China

e. From looking at these data, what conclusions can you draw about the relationship between how economically developed a region is and the growth rate of its population?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

CHOOSING THE NUMBER OF CHILDREN TO HAVE



As countries develop from agricultural to industrial economies, per capita incomes tend to rise and several factors which influence the choice to have children change. Some of those factors are listed below. For each factor, determine which of the above curves is affected (benefits or costs), which way the curve will shift (up or down), and what effect this will have on the desired number of children (more or fewer).

Change	Curve Affected	Direction of Shift	Change in No. of Children
a. Child labor laws are passed, restricting the ability of children to work.			
b. A social security system which provides income for those over certain age is instituted.			
c. Universal compulsory education is mandated to improve the nation's literacy rate.			
d. Educational and employment opportunities are more open to women.			
e. Infant mortality decreases.			

ACTIVITY 4

MATHEMATICAL PROGRESSIONS AND MALTHUSIAN PROJECTIONS

Thomas Malthus (1766-1834) predicted that population growth would eventually exceed a country's ability to increase its agricultural production. He based this prediction on his belief that while agricultural production increases arithmetically, population increases geometrically:

Arithmetic progression: A sequence of terms each of which (after the first) is found by adding to the preceding one a constant amount.
Examples: 2, 4, 6, 8, 10, ... ("2" is added each time)
23, 30, 37, 44, ... ("7" is added each time)

Geometric progression: A sequence of terms each of which (after the first) is found by multiplying the preceding one by a constant amount.
Examples: 2, 4, 8, 16, 32, ... (multiplying by "2")
10, 50, 250, 1250, ... (multiplying by "5")

Given this, complete the following:

i. Create an arithmetic and geometric progression beginning with 7 and using 3 as the constant factor.

ii. Suppose that agricultural production is currently at 100 units (one unit being enough to feed one thousand people) and that production is expected to increase by 10 units every 10 years. Next suppose that population is currently at 2000 and that it is expected to double every 10 years. Do the following:

a. Find the projected amount of agricultural production in each decade for the next century.

b. Find the projected population in each decade for the next century.

c. Are the sequence of values in (a) and (b) arithmetic or geometric?

d. When does the agricultural production become insufficient to support the population?

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

TOWARD A SUSTAINABLE FUTURE?

INTRODUCTION

Economic development (an increase in the per capita amount of goods and services produced by an economy) requires inputs from stocks of capital, stocks of natural resources, people, and knowledge. If natural resource stocks are depleted (either in quality or quantity), their capacity to supply the raw materials and energy needed to produce products in the future will be reduced. Thus, investment in their protection is essential to sustain any level of economic activity (or to foster any increases).

But such investment is possible only if economic development has been sufficient to meet society's basic needs. So, environmental protection is necessary to sustain economic development, and economic development is necessary in turn to provide environmental protection: each promotes the other. In this lesson students explore these linkages and the concept of sustainability.

ECONOMIC CONCEPTS

Sustainable Development
Economic Development
Capital
Technology
Technological Advance
Standard of Living

ENVIRONMENTAL CONCEPTS

Environmental Quality

OBJECTIVES

- Explain the relationship between economic development and the production of environmental quality.
- Discuss the role of environmental protection in sustaining economic development.
- Consider possible future growth scenarios.

LESSON DESCRIPTION

Students make choices concerning their own standard of living. The choice activity shows why there tends to be a positive relationship between economic development and environment quality. The management of a cash prize is used to explore ways in which a society's resource base is best managed. Finally, students look into their crystal balls and forecast their own future.

TIME REQUIRED

One class period

MATERIALS

One copy for each student of Activities 1, 2, and 3

PROCEDURE

Economic Development and the Demand for Environmental Quality

1. Explain that the following simulation illustrates why economic development in general also leads to an increase in environmental quality.
2. Distribute a copy of Activity 1. This Activity describes the general level of various product categories required to achieve four standards of living. Tell the students to suppose that they are currently living at the subsistence level in all categories. Tell them that you are to be their benefactor and will provide them with "upgrades" to use as they like. Each upgrade allows them to move to the next higher standard of living in one of the

categories. The only restriction is that no moves to the HIGH level of any product category can be made until all other categories are at least at the LOW level.

Begin by offering each student one upgrade. Ask each student to draw a circle around the new level he or she would choose first (for example, circle LOW under the FOOD category) and then place a "1" by it to signify it was the first choice. Offer the class a second upgrade and again have each student circle his or her choice and place a "2" by it. Have the class continue in this manner until everybody has used 20 upgrades. Allow 10 minutes.

3. After everyone is done, ask which turn (the 6th, 10th, 14th?) was used to upgrade ENVIRONMENTAL QUALITY to LOW. Also ask how many ended up at the LOW, MEDIUM, and HIGH levels for ENVIRONMENTAL QUALITY. Discuss responses.

   Typically, environmental quality is not one of the first choices for upgrading (other needs and wants are seen as more pressing), and few students place it at the HIGH level.

4. Conclude by emphasizing that environmental quality is a product people start demanding (and economies start "producing" by devoting resources to waste management or to non-consumptive uses) only after many other needs and some wants are met. Because of this, and contrary to what one might expect, the environmental quality of industrialized nations (where there is a lot of production) tends to be better than that of developing nations. Developing nations must devote most of their resources to food, clothing and other essential products; they often do not have the "luxury" of choosing to allocate resources to environmental quality.

Lotto, Account Management, and Sustainability

5. Announce the following to the class: This class has just won a big state lottery — $100,000! An account has been established at a local investment firm where a 10% return is guaranteed. Every year a check equal to 10% of the account's balance will be sent to you to do with as you please.
6. Ask students to suggest what might be done with this check — e.g., by spending and/or reinvesting it. Present several options and describe the effect of each option on the account balance and the size of future checks.
   a. Don't spend the 10% but instead reinvest it in the account; this tactic will increase the account balance and the size of future checks.
   b. Spend part of the 10% and add the rest to the account; this tactic will also increase the account balance and the size of future checks, but not by as much as in (a).
   c. Spend all of the 10% earned each year, keeping the account balance at $100,000 and future checks at $10,000.
   d. Spend more than the 10% each year, slowly depleting the account over time and reducing the size of future checks.
   e. Spend all of the $100,000 today so that no checks are received in the future.
7. Ask students to discuss which of these options each of them would

prefer. Next note that society essentially faces the same type of choice. The "account balance" is its stock of available resources and its technical knowledge. The "check" is the flow of services and materials these resources can supply each year to produce various products. "Spending" would refer to the production of consumer goods and services. Distribute a copy of Activity 2 (which illustrates the parallel between managing the lotto winnings and society's problem of managing its resource stocks).

8. **Ask: In what ways could the "check" be reinvested in society's account? Discuss responses.**

   By using the resource flows (S and M) to produce more capital goods (increasing T), to conduct research and development (increasing K), and to expand waste management activities or not harvest all the growth of renewable resource stocks (increasing E).

9. **Ask: Why might it be necessary here (unlike the case of the lotto account) for some of the check to be reinvested in order to keep society's "account balance" from falling? Discuss responses.**

   Capital depreciates (tools and machines wear out) with use, so some reinvestment in capital production is necessary to maintain the size of T. The use of nonrenewable resources reduces E. These losses could be offset by development of more renewable resource stocks to supply material flows in the future, by producing more capital and substituting for the nonrenewable resources (for example, producing insulation to reduce the need for energy resources), or by use of improved technical knowledge. Finally, even renewable resources like soil and wilderness areas can be depreciated with use or by pollution; responding to such depreciation requires investment in waste management and preservation activities.

10. **Ask students to reconsider options (a-e) above in this new context and to discuss the meaning and desirability of each. Discuss responses.**

    Most discussion will center on options (b) and (c). Option (a) essentially means no resources are devoted to consumer goods and services — no food, no clothing, no shelter, nothing — not a desirable choice if one wishes to see the human race survive. Options (d) and (e) violate most students' sense of fairness to future generations and their intuitive concept of "sustainability." Note that if sustaining the level of the account is important, some reinvestment as noted above is necessary, so option (c) may not meet this criterion.

11. **Define sustainable development as increases in the per capita production of goods and services which can be supported by the resource base now and in the future. Sustainable development is most likely to be achieved with an option like (b).**

12. **As a reminder of the meaning of "sustainability," close out this section by noting that the letters of the stocks which make up the "account balance" spell KEPT — i.e., that which is "maintained, protected, or guarded."**

Sustainable Economic Development

13. Distribute a copy of Activity 3 to each student. This activity shows four possible future paths of a country's standard of living (some measure of the quantity and quality of goods and services people receive: see Economics Extension Activity).
14. Divide the class into four groups. Assign each group one of the four scenarios. Assign each group to develop arguments explaining why its scenario is likely to be realized in the future. Ask the groups to base their arguments on the stocks described in Activity 2 (KEPT). Allow 15-20 minutes. One representative of each group should report to the class. Possible arguments follow.

    Scenario A: Technological advance is probably the key here. With it, increased production of products is possible without increasing the flows from T, E, or P. If the increase is large enough, a society could also divert more to reinvestment in T, E, and K, increase its stocks, and achieve even greater flows in the future. Some control of the growth of P might also be mentioned, so that the greater flows go to increasing the standard of living and not simply to supporting a larger population.

    Scenario B: The world population growth rate is already starting to slow down, thus slowing the growth of P. There are probably diminishing returns with respect to T increases and even with respect to technological advance, K. Nonrenewable resources (a flow from E) will soon be used up. A smooth transition to renewable resources and solar energy prevents any major collapse.

    Scenario C: Our reliance on nonrenewable resources is much greater than our renewable resources can support. Population growth outruns the ability of the economy to produce productive jobs. Lack of reinvestment in E has eroded its ability to provide flows. Production and population crash. A new, but much lower standard of living is supported by renewable resource flows.

    Scenario D: Flows from the environment basically stop as resource stocks are depleted, species become extinct and global environmental calamities (ozone depletion and global warming) occur: Mother Nature has her revenge!
15. Ask the class to discuss which scenario seems most likely and why. Discuss responses.

    Scenario A is probably overly optimistic (it assumes that the physical limits of the natural resource base can always be extended by technological advance), while Scenario D is probably too pessimistic (it ignores the sustainable flows possible from renewable resources). The issue is really one of whether or not there will be a smooth transition to a higher, sustainable standard of living (Scenario B) or a painful drop to a lower one (Scenario C). To a large extent, the outcome is likely to depend upon how much society's resource-allocation decisions reflect the value and costs of the various alternatives (i.e., produce consumer products,

produce capital goods, devote to waste management activities, or leave in site to produce environmental quality).

EXTENSION ACTIVITIES

Economics

16. Often *economic development* is defined as an increase in the per capita output of an economy. Note that this increase is typically measured in terms of a country's per capita Gross Domestic Product or GDP (the total market value of all final goods and services produced annually within the boundaries of a country). Ask: Why might this not be a good indicator of how well-off people really are? Discuss responses.

    GDP includes only marketed products, so the value of goods and services that do not pass through markets — such as environmental quality and leisure time — are not counted. GDP includes capital goods which are being produced only to replace other capital which has worn out (this could be corrected by considering net domestic product). GDP also does not take into account the depletion of natural resource stocks.

17. Assign students to construct and discuss their own measures of a society's "standard of living."

Science

18. Increased energy efficiency means decreased used of energy resources for products requiring power. In this way, society gets the same services from the product but uses fewer resources — an example of how new knowledge allows society to get more from a fixed quantity of resources. Assign each student to select a product which uses energy (hair dryer, vacuum, refrigerator, car, washing machine, television set, microwave oven, etc.) and investigate how the amount of energy required to operate the product has changed over the last 30 years. What explains the change? A letter to the public relations division of the product manufacturer is the best place to start.

ACTIVITY 1

CHOOSING A STANDARD OF LIVING

The requirements of the products below are stated in terms of the following standards of living:

SURVIVAL:	Subsistence living, life expectancy under 40 years.
LOW:	Equivalent to a rural village in a third-world nation.
MEDIUM:	Equivalent to low-middle income life in the U.S.
HIGH:	Equivalent to middle-high income life in the U.S.

FOOD

SURVIVAL:	Most nutritional requirements unmet, near starvation.
LOW:	Some nutritional requirements unmet, little variety in foods.
MEDIUM:	Most nutritional requirements can be met, some variety in foods.
HIGH:	All nutritional requirements can be met, great variety in foods.

CLOTHING

SURVIVAL:	A few basic essentials ("the shirt on your back").
LOW:	Several essential items.
MEDIUM:	Plenty of essential items, a few formal items.
HIGH:	A "complete" wardrobe.

SHELTER/HOUSING

SURVIVAL:	A shelter containing sleeping and cooking area, no indoor restroom facilities.
LOW:	Two rooms, cooking area is separated from the rest of the "house," no indoor restroom facilities.
MEDIUM:	House with separated cooking, sleeping, and living areas, indoor restroom facilities.
HIGH:	House as in MEDIUM with extra rooms for guests, recreation, or for each child to have separate bedroom.

MEDICAL CARE

SURVIVAL:	None.
LOW:	Some medicines.
MEDIUM:	Vaccinations, emergency care, most medicines.
HIGH:	Emergency and preventive care, health insurance.

TRANSPORTATION

SURVIVAL:	None.
LOW:	Limited bus or rail access.
MEDIUM:	Older model car, mass transit, bus and rail access.
HIGH:	Newer model car, air transit.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 1

COMMUNICATIONS

SURVIVAL:	None.
LOW:	Limited access to radio or telephone.
MEDIUM:	Radio, telephone, television.
HIGH:	Cable TV, telephone, computer.

ENVIRONMENTAL QUALITY

SURVIVAL:	No control or treatment of wastes.
LOW:	Wastes dumped away from living areas, poor air and water quality.
MEDIUM:	Sewage system, some emissions control, fair air and water quality.
HIGH:	Most wastes managed, good air and water quality, access to wilderness areas and wildlife preserves.

INFRASTRUCTURE

SURVIVAL:	None.
LOW:	Community water well and commons.
MEDIUM:	Roads, most utilities, fire and police protection.
HIGH:	MEDIUM plus libraries, museums, community centers, public recreational facilities.

EDUCATION FOR CHILDREN

SURVIVAL:	Some informal cultural, social, and language training at home.
LOW:	Some formal schooling at the elementary level.
MEDIUM:	Formal schooling through most of the secondary level.
HIGH:	Training or college beyond the secondary level.

EXTRAS

SURVIVAL:	None.
LOW:	Some personal items, tools, cooking utensils.
MEDIUM:	Some appliances, furniture, going out to movies.
HIGH:	Vacations, entertainment center, regular dining out, a motor boat.

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 2

SUSTAINABLE ECONOMIC DEVELOPMENT

ACCOUNT BALANCE = K + E + P + T

A society's account balance is the stock of knowledge and resources it possesses where:

K = its stock of Knowledge (technical "know-how" for converting resources into goods and services)
E = its stock of Environmental resources ("natural capital" including minerals, fossil fuels, plant and animal species, soil, water, air, rangelands, and natural habitats)
P = its stock of People (human resources)
T = its stock of Tools ("physical capital" including buildings, machines, hammers, saws, tractors, and assembly lines)

THE CHECK

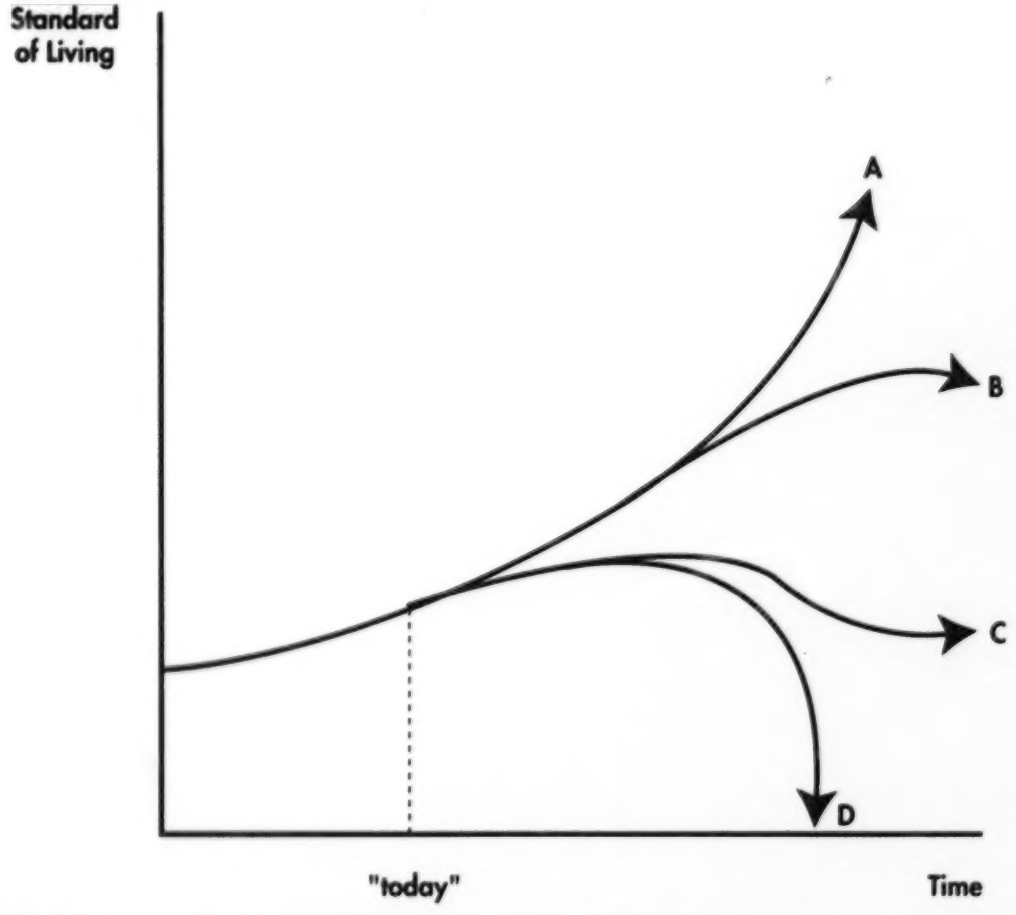
The "check" society receives each year is the flow of services (S) and materials (M) from the stocks (above), which it can use to produce the goods and services it desires.

S = labor services from P, productive services from T, solar services from E, assimilative and amenity services from E
M = extracted and harvested natural resources from E

From ***Economics and the Environment;*** *©National Council on Economic Education, New York, NY*

ACTIVITY 3

POSSIBLE FUTURES



SCENARIO A: The standard of living continues to rise forever.

SCENARIO B: The standard of living continues to rise but this growth slows and eventually stops. The standard of living then is sustained at this level forever.

SCENARIO C: As in Scenario B, the standard of living eventually reaches a level which is sustained forever. However, this level is lower, and the economy initially "overshoots" it, requiring a difficult transition periods when the standard of living actually falls.

SCENARIO D: No level of the standard of living is sustainable. The standard of living continues to grow for a while and then completely collapses.

GLOSSARY

Acid rain (or precipitation). Rain or snow that has a lower pH than precipitation from unpolluted skies. (8,14)

Allocation of resources (resource allocation). The decision concerning how to use society's scarce resources (that is, deciding how much of society's resources will be devoted to producing each of the products society desires). (5)

Allocative efficiency. That allocation of resources to the production of goods and services which yields society the greatest value; for a single good or service it is that quantity of the good or service which yields society the greatest net value. (5,6,7,8,9,12)

Ambient standard. A never-exceed level of some pollutant in the surrounding environment; typically expressed in terms of an average concentration (i.e., micrograms per cubic meter, parts per million) over some time period. (5,13)

Amenity services. Services made possible with the existence (not consumption) of natural resources (for example, viewing a sunset, swimming in a lake, survival of a species, hiking in the wilderness). (1,9)

Asset. Anything of value owned by an individual or firm. (15)

Assimilation. The ability of the environment through natural processes to disperse, absorb, and transform wastes. (1)

Benefit. Value gained when a decision is made. (9,13)

Benefit-cost analysis. A study to decide whether to use resources (and if so how much for a particular good or service) by comparing the benefits received to the costs incurred. (9)

Biochemical oxygen demand (BOD). Amount of oxygen required by bacteria to break down a given amount of organic wastes in water. (4)

Biodiversity. A measure of the amount of genetic variability among individuals within a single species and the number of species within an ecosystem. (1)

Biological growth. The regeneration of a species through natural processes. (16)

Capital (capital goods). Tools of production; goods used to produce other goods and services (factories, machines, tools). (2,20)

Capital gain. The monetary gain realized when a resource or product is sold for a price greater than the price paid for it. (15)

CFCs (chlorofluorocarbons). Organic molecules consisting of chlorine and fluorine bonded with carbon; also known as freon gases, they are used primarily as a coolant (formerly also as a spray-can propellant until that use was banned in the U.S. in 1978). (7)

Change in demand. A situation where buyers, due to changes in tastes or income, are willing and able to buy more or less of a product at all possible prices. (18)

Change in supply. A situation where sellers, due to changes in costs of production, are willing and able to offer more or less of a product at all possible prices. (18)

Coase proposition. The idea that externalities can be resolved through private negotiations of the affected parties (regardless of who holds the property rights). (12)

Common law. Body of rules and principles based on judicial precedent rather than legislative enactments. (12)

Common property resource. A resource that is not exclusively owned or controlled by anyone. (6,16)

Consumption. The use of goods and services to satisfy wants. (1,2)
Contingent valuation. A survey technique in which people are directly asked how much they would be willing and able to pay for a given change. (10)
Cost (opportunity cost). Value forgone or lost when a decision is made. (4,9,13,18)
Cost-effectiveness. Achieving a goal in the least-costly manner possible. (5,14)
Demand. The quantity that buyers are willing and able to buy at all possible prices in a given period of time. (3,4,10,14)
Derived demand. The demand for a product or resource which is dependent on or related to the demand for some other product or resource (for example, the demand for a resource depends on the demand for the products it can be used to produce). (18)
Diminishing returns. A condition where (given a fixed amount of at least one resource), as more of other resources are used, a point is reached beyond which each additional resource unit adds less production than the one that came before. (19)
Dioxin. Any of a large group of highly toxic, cancer-causing compounds used primarily in producing herbicides. (11)
Economic development. Increases in a society's per capita production of goods and services. (19,20)
Economic growth. An outward shift of the production possibilities curve; an increase in the production of goods and services (typically measured by GDP). (19)
Economic incentive. Anything that encourages an individual or firm to behave or perform in a particular way in return for a monetary gain. (6,13,14,16)
Economic wants. People's desires that can be satisfied with goods and services. (1,2)
Emission charge. Special fee or tax levied on the basis of the amount of a pollutant discharged into the environment. (14)
Emission standard. A never-exceed amount of a pollutant permitted to be released from a source in a given time period. (13)
Energy. The capacity to do work, in many forms including heat, light, electricity, oil, and coal. (1,2)
Energy conversion. The transformation of energy resources into usable forms (for example, coal into electricity). (2)
Environment. All the natural conditions and influences surrounding and affecting life. (1)
Environmental quality. The quantity and quality of life-support products and amenity services received by individuals directly from the natural resources of the environment. (1,20)
Equilibrium. A condition wherein the quantity of a product demanded at a price is equal to the quantity supplied for sale at that price. (6,18)
Exclusion principle. Those who do not pay for a product are excluded from receiving any benefits from it. (7)
Externality. Any benefit or cost associated with the production or consumption of a good or service which is enjoyed by (without payment) or inflicted upon (without compensation) a party other than the buyer or seller of the good or service. (8)
Extinction. The elimination of a plant or animal species. (16)
Fossil fuel. Any one of the organic energy sources (coal, natural gas, oil) derived from once-living plants or animals. (2,14,15)

Four Rs. The four general ways to lower the throughput of natural resources: reduce, reuse, recycle, and refine. (2)

Free-rider problem. The inability of those who might produce a good or service which has shared consumption characteristics to obtain payment from those who benefit from it because the exclusion principle cannot be applied to it. (7)

Global warming. A hypothesized rise in the average temperature of the earth's surface due to heat being trapped in the atmosphere by "greenhouse gases." (4,14)

Goods. Tangible things, things that can be touched or seen, that satisfy human wants. (1,2)

Greenhouse gases. Gases emitted into the atmosphere that are thought to lead to an increase in global warming (including carbon dioxide, chlorofluorocarbons, methane, and nitrous oxide). (4)

Habitat. The specific region in which a species lives. (3)

Human resources. The physical and mental abilities people use to produce goods and services. (2)

Incineration. The burning of wastes at high temperatures. (1,2)

Interest rate. The percentage amount paid for the use of money (borrowed funds). (15)

Landfill. A solid waste disposal site where wastes are dumped and generally covered daily with a layer of dirt to reduce odors and pests ("sanitary landfill"). When lined by clay and synthetic liners in an attempt to prevent leakage, they are called "secured" landfills. (1,2)

Law of conservation of matter. The scientific principle that matter cannot be created or destroyed by non-nuclear processes. (2)

Law of demand. An economic principle that states that a greater quantity of a product will be sold at a lower price than at a higher price, everything else being equal. (3)

Life-support products. Clean air and water, protection from ultra-violet rays, habitat, etc. needed to sustain life. (1)

Market. Any setting where buyers and sellers establish prices and trade products. (6,14,18)

Materials processing. The transformation of natural resources into goods. (2)

Natural resources. Materials and productive services provided by the natural environment (coal, timber, fish, solar energy, soil, minerals, etc.). (1,2)

Negative externality. A cost imposed on a third party without compensation due to the production or consumption of a product by others. (8)

Net value. The benefit (or value) received minus the cost incurred. (5,9)

Non-marketed products. Goods or services which are not traded in markets (for example, ozone layer, wildlife preservation, scenic viewing). (10)

Nonrenewable resources. Natural resources whose total availability over any meaningful time period is fixed. (15)

Opportunity cost. The highest valued alternative that must be forgone when another option is chosen. (4)

Ozone layer. Thin layer of ozone molecules in the stratosphere which absorb ultraviolet light. (7)

pH. A measure of acidity on a scale from 0 to 14 — with pH 7 being neutral, numbers greater than seven being basic and numbers less than seven being acidic. (8)

Pollution. Reductions in environmental quality. (2,4)

Pollution costs. Value of forgone environmental quality or the costs associated with avoiding the effect of lost environmental quality. (4)

Pollution prevention costs. Costs to prevent, control, treat, or reduce pollution. (4)

Population growth. Percentage change in the number of people living in a given region. (19)

Positive externality. A benefit received freely by a third party due to the production or consumption of a product by others. (8)

Potential reserves. The amount of a resource which is conceivably recoverable. (17)

Present value. The value today of a benefit or cost received in the future; typically found by $PV = FV/(1+r)^n$, where PV is the present value, FV is the future benefit or cost, r is the interest rate, and n is the number of periods from today that the benefit or cost is received. (9)

Price (market price). The amount of money paid or received in markets for a unit of a good or service; measures the relative scarcity of products and resources. (3,6,15,17,18)

Private property. All resources and products that are owned and whose use is controlled by individuals or firms. (6)

Probability of death. The number of people who die as a result of some activity divided by the total number of people engaged in that activity. (11)

Product. Any good or service produced in the economy or provided directly to consumers by the natural resources of the environment. (1)

Production. The use of resources to create goods and services. (1,2)

Production possibilities curve. A curve which shows the different combinations of two goods or services that could feasibly be produced given full-employment of available resource supplies and a given level of technology. (1,4)

Productive resources. All resources (human, capital, and natural) used in the production of goods and services. (2)

Productivity. A ratio of output (goods and/or services) produced per unit of input (productive resources) over some time period (for example, output per worker per day). (19)

Property rights. Legal or social arrangements that govern the ownership, use, and exchange of goods and services. (6,12)

Public good/service. A good or service with shared consumption characteristics and to which the exclusion principle does not apply. (7)

Rate-of-return. Percentage gain from an asset. (15)

Recycling. Collecting, sorting, and processing wastes into usable natural resources for production. (1,2,18)

Renewable resource. A resource replaced by natural ecological cycles (water, plants, and animals) or natural chemical or physical processes (sunlight, wind). (16)

Reserve/production ratio. Known reserves divided by annual production; typically used as a measure of how many years it will be before the reserves are depleted. (17)

Reserves. Amount of a natural resource that is economically feasible to extract with current technology. (17)

Resource endowment. Amount of a resource that is physically available in the earth's crust. (17)

Rule of 70. A method for calculating the number of years it will take for a quantity to double (divide 70 by the growth rate of the quantity expressed in whole numbers). (19)

Scarcity. The central economic problem that results from the imbalance between relatively unlimited wants and the relatively limited resources available for satisfying those wants. (1)

Self-interest motives. The desire to do that which is in one's own best interest. (6)

Services. Physically intangible things or actions that satisfy human wants. (1,2)

Shared consumption. One person's use or consumption of a good does not reduce the amount available for others to consume. (7)

Social goals. Objectives for use in deciding how to use resources. (5)

Solar energy. Energy derived from the sun or natural phenomena driven by the sun (wind, running water, biomass). (15)

Species. A group of plants, animals, or microorganisms that have a high degree of similarity and generally can interbreed only among themselves. (16)

Standard of living. Some measure of the quantity and quality of goods and services consumed by an individual; often measured in terms of per capita GDP (gross domestic product). (20)

Statistical life. Life of a theoretical person who is unknown. (11)

Substitutes. Products which satisfy essentially the same want or need (for example, margarine and butter or air conditioning and a cool day). (10,17)

Supply. The quantity that sellers are willing and able to offer for sale at all possible prices in a given period of time. (4,14)

Sustainable development. Increases in the per capita production of goods and services, including environmental quality, which can be supported by the resource base and technological advance now and in the future. (20)

Sustained yield. Use of renewable resources in such a way that they are not destroyed and can generate a continued flow of natural resources in the future. (16)

Technological advance. An increase in technical "know-how" (see "technology"). (20)

Technology. The body of knowledge that can be used to produce goods and services from resources; additions to this knowledge are called "technological advance." (19,20)

Technology-based standard. Emissions control based on requiring the use of a specific practice, process, or equipment. (13)

Total fertility rate (TFR). The number of children an average woman living in a given region is expected to have in her lifetime. (19)

Tradable permits. A license to emit a certain quantity of some pollutant in a specified time period; the license can be sold to others. (14)

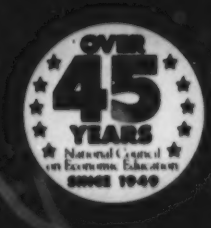
Trade-off. Getting a little more of one thing in exchange for a little less of something else. (1)

Value (economic value). The ability of a good or service to satisfy an individual's want or need; typically measured by the amount of goods and services the individual is willing and able to sacrifice in order to obtain the good or service (usually expressed as the amount the individual is willing and able to pay). (3,4,10,11)

Waste management. The treatment, recycling, incineration, landfilling, and/or storage of wastes. (1,2)

Wastes. Unwanted natural resource by-products of energy conversion, production, and consumption activities. (1,2)

Water rights. The property rights defined for water ownership and use. (6)
Well-defined property rights. Property rights with the following four characteristics: universality, exclusivity, transferability, and enforceability. (6)
Zero population growth (ZPG). A condition in which population is not increasing or decreasing (the population growth rate is zero percent). (19)



Economics America

Economic Education

251